INTERNATIONAL SPACE UNIVERSITY

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New Space Markets

Edited by
G. Haskell and M. Rycroft

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NEW SPACE MARKETS

SPACE STUDIES

VOLUME 2

Editor

Prof. MICHAEL RYCROFT

International Space University

Excellence in space education for a changing world

The International Space University (ISU) is dedicated to the development of outer space for peaceful purposes through international and interdiscliplinary education and research. ISU works in association with a number of Affiliates (universities, research institutes, consortia ...) around the world and in partnership with space agencies and industry.

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NEW SPACE MARKETS

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Table of Contents

Acknowledgements xi
Foreword xiii

Keynote Address: Space Transportation Systems -Enlarging the Market (**C. Bigot**) 1

Session 1
Strategic Issues: National Perspectives (European and American)
Session Chair: **K. Doetsch** 11

Partnership Between CNES and Industry : A New Market Oriented Approach (**P. Clerc**) 13
How National Space Activities May Be Integrated Into The Economic Mainstream (**K. Saul**) 23
How to Encourage Industry to Reach New Space Markets and to Develop Space Commercialisation (**A.-M. Hieronimus-Leuba, P. Willekens**) 31
Government as a Customer for New Space Services (**P. Norris**) 37
Combining Technical and Business Ingenuity to Create a Robust and Adaptable Marketplace that Anticipates, Meets and Exceeds Customer Needs (**R. Hornstein**) 45

Report on Panel Discussion 1 55

Session 2
Strategic Issues: National Perspectives (Developing Countries)
Session Chair: **J. Adamson** 57

A Pragmatic Approach to Increase the Capacity of Developing Countries to Adapt and Develop Remote Sensing Technology (**A. Jayasekara**) 59
Integration of Remote Sensing Technology into Local Markets : A Policy Analysis (**N. Ochanda**) 67
China and the International Space Market (**G. Zheng, W. He**) 75

Report on Panel Discussion 2 83

Keynote Address: New Markets: The Role of Exploration (**M. Mott**) 85

Session 3
Strategic Issues: Global Perspectives
Session Chair: **R. Doré** 93

International Space Cooperation Applied to New Space Markets (**I. Pryke, G. Gibbs**) 95
Space Activity at the Threshold of the 21st Century: A Geopolitical and Geoeconomic Perspective (**G. Khozin**) 107
The Economics of the European Space Industry: The Impact of the European Military Space Market on Structure, Conduct and Performance (**V. Zervos**) ... 117
Changes in the Satellite Communications Industry as Seen by a Global Supplier (**F. Dodu**) 125

Report on Panel Discussion 3 133

Session 4
Strategic Issues: Business Perspectives of Space Opportunities
Session Chair: **P. I. Yu** 135

Featured Address: Privatization of Space Flight Operations (**J. Adamson**) ... 137

Market Strategy and Ethics (**G. Pandozy**) 145
Potential of Hands-On Venture Capital for Space-Related Growth Companies (**J. Kreisel, K. Nathusius**) 153

Report on Panel Discussion 4 163

Keynote Address: Wall Street: The New Launching Site for Space Projects (**M. Leroux**) 165

Session 5
Teleservices
Session Chair: **H. Chasia** 171

A Commercial Satellite-University Joint Venture in DBS Markets: Creating Future Tele-education Markets Via Satellite (**R. Brouard**) 173
Trends Toward the Development of a New Potential Space Market Providing Satellite Based Telemedical Services (**P.H.U. Lee, F. Wangusi**) 181
Space Assets in the Emerging Telemedicine Market (**P. Cohendet, L. Valignon**) 191
Government and Commercial Space: Communications Satellites (**D. Whalen**) 199

Report on Panel Discussion 5 209

Session 6
Markets for 2020?
Session Chair: **P. Diamandis** 211

The X PRIZE Competition (**P. Diamandis**) 213
Facilitating a New Space Market Through a Lunar Economic Development Authority (**P. Harris**) 223
Extraterrestrial Resource Exploitation (**C. Welch, D. Wade**) 233
International Market for a Reusable Launch Vehicle (**O. Ferrandon**) 243

Report on Panel Discussion 6 253

Keynote Address: New Space Markets, Eternal Human Needs (**N. Samara**) . 255

Session 7
Earth Observations: Market or Public Service?
Session Chair: **M. Kabbaj** 261

The Use of Meteorological Satellite Data in Africa and Their Contribution Towards Economic Development (**T. Tadesse**) 263
From Technology Push to Market Pull : SPOT, a Success Story (**J. Mouysset**)... 269
Identification of Satellite Data Application Products and User Requirements in Argentina: Influence on Strategic Planning (**R. Hipp, H. Karszenbaum**).... 275
Satellite Remote Sensing and Maintaining Environmental Security: The Market Perspective (**R. Williamson**) 283
Into the 21st Century With Industrial Partners: The Indian Experience and Perspectives in Earth Observation (**M. Sebastian, M. G. Chandrasekhar, U.R. Rao**) 291

Report on Panel Discussion 7 301

Session 8
Technological Issues
Session Chair: **S. La Pensée** 303

Micro- & Nano-technologies : A Challenge on the Way Forward to New Space Markets (**J. Benoit** 305
Space Technology Transfer as a Source of Innovations (**G. Kraft**) 313
The International Space Station : A New Space Market (**J. Tailhades**) 321

Report on Panel Discussion 8 327

Poster Papers 329

New Space Markets: Understanding the Security Rationale (**A. Tarassov**) ... 331
In Step with the World - Entrepreneurial Approach to New Space Markets (**A. Desai**) 337
Global Operations for the Next Century (**J. J. Cunningham, H. M. Rehorst**) ... 339
Constellation Design and Development for Efficient Manufacture and Operation (**D.I. Wade, C.S. Welch**) 341
The Grand-Bassin Case Study: A Step In Sustainable Development (**A. Celeste, J.-D. Lan Sun Luk**) 343
A Brief Account of the General Organization of Remote Sensing (GORS) in Syria and its Activities (**H. Ibrahim, M. Koudmani**) 345
Legal and Regulatory Aspects of the Future International Global Navigation Satellite System (**P. A. Salin**) 347

Session 9
Symposium Conclusions: The Way Forward
Session Chair: **E. Triana** 349

Report on Panel Discussion 9 351

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Foreword

G. Haskell, Symposium Convenor, Vice President for Academic Services and Outreach, International Space University

M. Rycroft, Senior Faculty Member, International Space University

For the theme for the second in its series of annual symposia, the International Space University (ISU) chose "New Space Markets". The symposium covered these from the unique perspectives of ISU, which are interdisciplinary, international and intercultural.

Communication, education, science, healthcare, meteorology, food and energy production, resource management, conflict mitigation, environmental protection, development of new materials... These and other essential sectors require space technology, particularly Earth remote sensing and telecommunications.

Space is no longer the special, protected domain that it was in the past but is becoming integrated into the mainstream of economic activity. Technology push is giving way to the assessment of market opportunities and demand pull. Funding from the public sector is declining while interest in private financing is steadily growing. The value-added and service industries are increasing in importance. New technologies will be developed in a context of privatization, de-regulation and globalization.

The objective of the Symposium was to bring together a diverse group of people, technical and non-technical, engaged in the creation of new approaches to space applications, in order to share experiences and to exchange ideas on the way forward.

In order to promote cross-fertilization between sectors of activity and between technical and non-technical aspects, all presentations were made in plenary session, i.e. there were no splinter sessions.

Among the challenging questions addressed were:

- How can space activities be better integrated into the economic mainstream?
- Will market forces satisfy national needs, especially those of Developing Countries?

- Are the greatest opportunities in the space segment, the ground segment, "spin-off", or in "spin-in"?
- How should scientific innovation, technological development and new applications be encouraged, financed and successfully brought to the market-place?
- Where can entrepreneurial value-added and service sectors best contribute?
- What are the new geopolitical opportunities and constraints?

Among the 160 people attending the Symposium were members of the second Master of Space Studies class, young professionals and postgraduate students who are developing the Symposium's theme in their Team Project. Their report will be completed at the end of July 1997.

Keynote Address

Space Transportation Systems -Enlarging the Market

C. Bigot, Chairman & CEO, Arianespace, B.P. 177, Boulevard de l'Europe, 91006 Evry Cedex, France

1. Introduction

Thank you for giving me an opportunity to speak about the Space Business and, more specifically, about the Space Transportation business. This international symposium, organized by ISU, is dedicated to the "New Space Market". We are all concerned by this important subject, which drives our future activities.

Before starting, let me make some preliminary remarks.

- When we speak about a "New Space Market", we often confuse some new needs, which can be detected from the Market, and the possibility for these needs to become a real Market, when the revenues can cover all the costs. To speak of a real Market, profitability has to be demonstrated and the implementation of the new systems has to be qualified.
- This is particularly true in space as the volume of governments' activities is so important (specially for military purposes) that some civil applications can survive only because the governments support the main part of the fixed cost and even, sometimes, part of the exploitation costs.
- Moreover, many civil applications are directly derived from military programs or, at least, can be implemented only thanks to the high level of technology developed by the governments for strategic reasons.
- On the other hand, space governmental activities are taking great advantage of the commercial market, which increases not only the regularity, and thus the reliability, but also the volume of the total activities and, in consequence, decreases the total costs.

To conclude these preliminary remarks, we have to remember that space activities are essentially the result of two complementary objectives, which cannot be dissociated, and which gain mutual benefit from each other: these are the strategic objectives of the governments and the commercial objectives of the Market.

This being said, let me come back to our subject: "New Space Markets". My presentation will be in two parts :

a) The changing needs for access to space, and
b) Consequences for the space transportation business.

2. Evolution of Space Access Needs

2.1 Preamble

At the present time, everybody agrees that there is an **Evolution** in the Space Market, or maybe more than an evolution. Some are speaking of a **Revolution**, others of an **Explosion**. Let us be more realistic, and I propose to consider this evolution in three aspects :

- A very rapid expansion of the <u>telecommunications</u> needs, which remain by far the main space application.
- An increase of <u>other space applications</u>, such as remote sensing, meteorology and Earth observation, with a clear tendency for international consolidation of these needs.
- More international cooperation for <u>strategic or scientific purposes</u>, as is, for example, demonstrated by the International Space Station.

I do not want to enter into the details of these different aspects, which will be the task of many specialists during this symposium. What I try to do is to have a simple look at each of them in order to see how Space Transportation is concerned in these new ways of enlarging the Space Market.

2.2 Telecommunications

Telecommunications are the major space applications since Arthur C. Clarke, fifty years ago, described the advantages of the geosynchronous orbit (GEO). Twenty years after that, Early Bird opened the way and some other systems followed. However, we only began to speak concretely about the Space Telecommunications business twenty years later, in the middle of the nineteen eighties, only ten years ago.

In those ten years, the evolution has been dramatic, so that a telecommunications satellite which started as a single relay from ground to ground is now an element of the future data highway in the sky. The ultimate goal is to allow everybody to communicate to anybody from anywhere to anywhere.

Today, the needs of the Telecommunications Market are evolving in three directions:

- **Telephony** for mobile communications, which implies various solutions, from low orbit with many small satellites (constellations in LEO), to medium orbit with medium size satellites (constellations in MEO), or large satellites to GEO.
- **Direct TV** which requires very large satellites with high power in GEO, and digital techniques associated with frequency compression.
- **Data transmission** with large bandwidth and very high power, using either a LEO constellation or giant GEO satellites.

2.3 Other Applications

The remote sensing market is evolving very rapidly in two different ways:

The government sector. For large governmental needs, we observe a general tendency for a shift from purely national or bilateral programs, which were traditionally the case up to now, towards more regional or worldwide programs, through international organizations. For meteorology, the traditional national or European agencies (NOAA, JMA, ISRO, SMA, GOMS, EUMETSAT...) are coordinated through the World Meteorological Organization (WMO). For Earth observations, the national systems (EOSAT, LANDSAT, JERS, SPOT, IRS, RADARSAT, RESURS, SCS...) are more and more integrated in multilateral or international programs (HELIOS, ADEOS, MIR activity...).

The private sector. The private sector is now very interested by less complicated remote sensing platforms, with high performance, and the Market is starting for small or medium satellites in low Earth orbit for such commercial applications.

2.4 Strategic Governmental Needs

Science and technology . Developments here are two sources for innovative new ways, using either more and more small micro or mini satellites for faster, better and cheaper missions, sometimes as auxiliary payloads, or a very few but prestigious main international scientific missions for exploration of the Universe.

The International Space Station. A very interesting source of space transportation requirements, to be implemented in an international frame.

3. Space Transportation Aspect

3.1 The Future Needs for Space Transportation

For the classical market in geostationary orbit, there are two major trends for the new needs:

- Masses are increasing dramatically (Figure 1), more than expected, and will continue to increase; we can foresee a GTO satellite of 6 to 8 tonnes which, today, can be launched only by Ariane 5 on the commercial market.
- The so called "standard" GTO orbit is no longer the preferred solution to go to the final GEO due to the possibility of more sophisticated (namely electrical) propulsion systems on board the satellite. We have now to consider various altitudes of the perigee, from 200 km (classical) up to 10,000 km or 20,000 km. We must now offer launch services for many different GTO missions, including the direct injection into GEO.

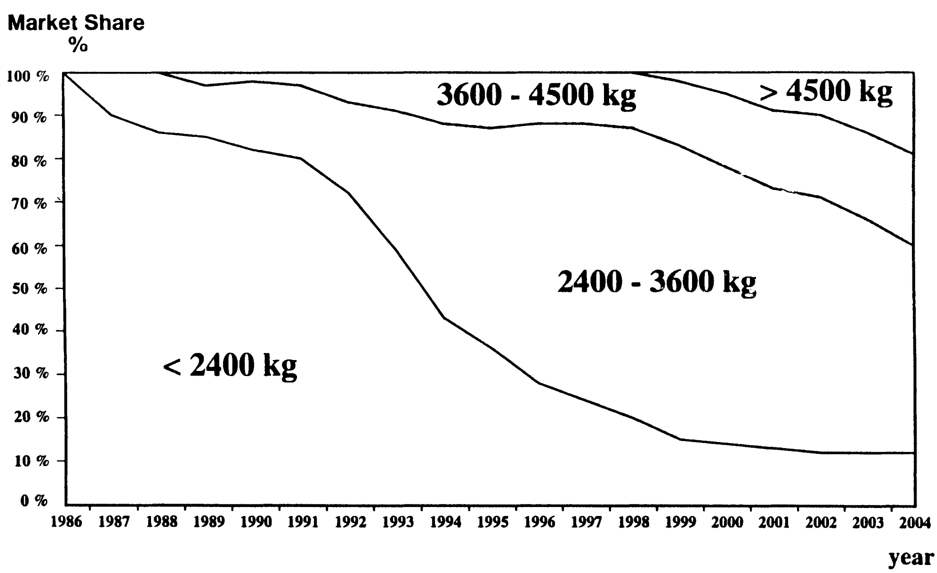


Figure 1. Evolution of satellite mass distribution

A very large variety of missions for space applications is now necessary for satellite constellations. These are composed of several or many small, medium or heavy satellites in extremely different orbits at various altitudes (LEO, MEO, GEO), and various inclinations.

Many constellations are today considered (Figure 2), with a high diversity:

- The weight of the satellites varies from 50 kg (Orbcom, GE Starsys ...) through 500 kg and more (Globalstar, Iridium, Teledesic, Skybridge, etc...) to a few tons (ICO, Odyssey, Spaceway...).
- The number of satellites for one system varies from a few (5 to 10) in a high orbit, up to about 1,000 for low orbit.

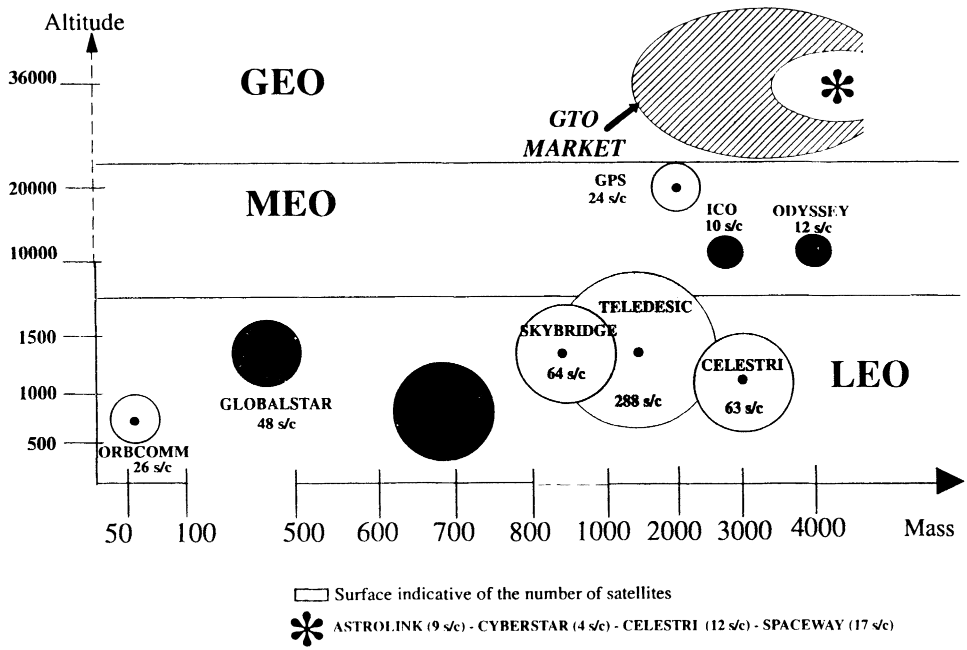


Figure 2. Diagram illustrating altitude and mass of various satellite constellations

Specific missions must also be considered for scientific purposes (all types of trajectories, including escape) and for servicing of the Space Station (delivery of freight or human flights).

3.2 The Arianespace Answer to the Market Needs

Arianespace is very proud of having supported very effectively the commercial market. With 100 launches, Arianespace put into orbit 150 satellites, of which 86% are for space telecommunications, with an excellent reliability (Figure 3). Today, there are around the Earth 140 operational Telecommunications civil satellites, out of which 100 have been launched by Arianespace.

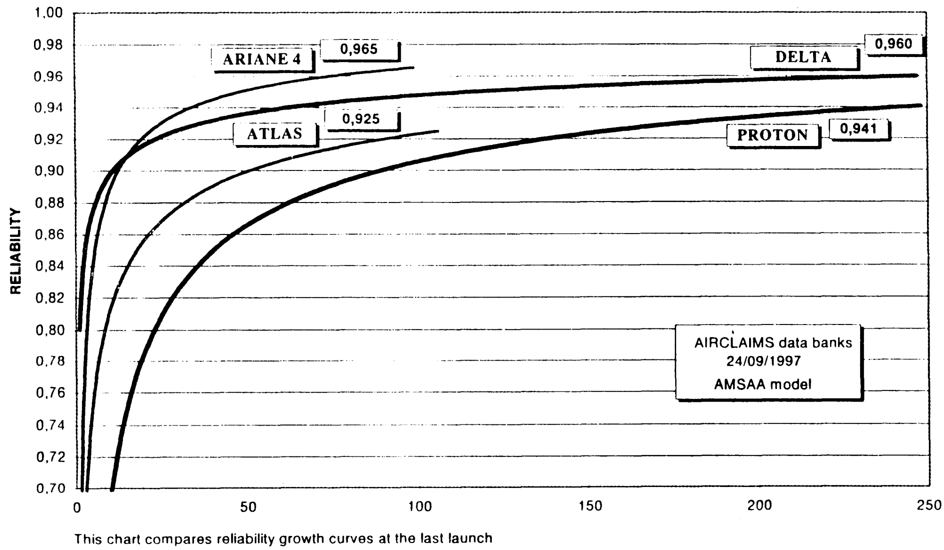


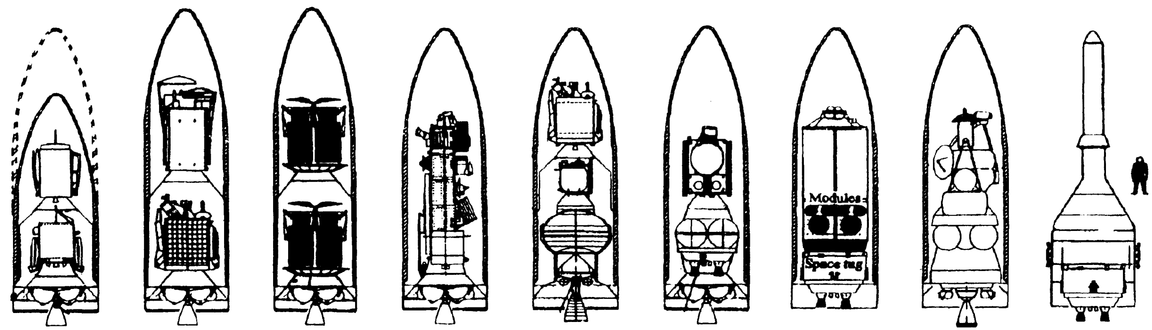
Figure 3. Reliability of different launch vehicles as a function of number of launches

Arianespace intends to continue its service for the benefit of space users, and must soon take some crucial decisions.

Ariane 5 is well suited today to the GTO missions, but must be adapted to the future of the whole GEO market:

- Increase of performance for GTO and GEO, up to 8 to 10 tonnes in GTO.
- Cost-effectiveness
- Manoeuvrability for direct GEO injection, but also for some MEO and LEO constellations, and for many other specific missions : scientific, servicing of stations, human flight, exploration of the Universe (Figure 4).

arianespace **EVOLUTION D'ARIANE 5 VERS UN SYSTEME COMPLET DE TRANSPORT SPATIAL**



Charge Utile	Un à deux satellites	Deux satellites	Constellation	Plate-forme polaire *(Envisat)*	Un à deux satellites	Un à deux satellites	Remorqueur Spatial (ATV)	Exploration Spatiale	Vol habité
Mission	GTO	GTO	LEO, MEO	SSO	GEO	GEO	LEO	Lunar or planetary	LEO
Configuration	Coiffe Courte Carrying struct. Sylda5	Coiffe Courte Carrying struct. Speltra	Coiffe Courte Carrying struct. Speltra	Coiffe Longue	Coiffe Longue Internal struct. Sylda5	Coiffe Longue	Coiffe Longue	Coiffe Longue	Capsule Utility Module

UN VASTE DOMAINE DE MISSIONS POSSIBLES

Figure 4: Diagram illustrating various satellites that can be launched using Ariane 5

For LEO or MEO constellations, Ariane 5, even adapted, may not be the best solution, and the question is obviously raised for Arianespace about the need for new launchers, complementary to Ariane 5. For the past few years, Arianespace and its European partners have analysed the situation and two solutions are still contemplated:

Development of a new, small or medium European launcher. There are many advantages in this solution, especially if the new launcher is designed to use much of the hardware existing on Ariane 5 (equipment, subsystems, and complete stages as, for example, the solid propellant booster P230). This commonality between Ariane 5 and the future complementary launcher will permit safe and quick development, and lower manufacturing and operational costs, so that European industry will benefit from an increase in business. Many projects have been studied and some of them are still being considered. Some drawbacks remain, however.

- Time is of the essence, and Arianespace wants to be in the market as soon as possible.
- Development costs, even if reduced by the commonality with Ariane 5, still remain too high for a strong competitivity.
- An entirely European system is not a good way for cooperation!

International cooperation. The other solution could indeed be a cooperative one. There are today some small or medium launchers, fully available throughout the world; why not use them ? This cooperation could also be an excellent opportunity for Arianespace to start a real relationship with other launch providers, with two or three "rules of the road":

- Complementarity will replace competition.
- Both parties will benefit from the cooperation: Arianespace will propose its expertise for commercialisation and the partner will supply the launcher or the launch system.
- There are prospects for a common approach to the future market.

3.3 International Cooperation

The Space Transportation business for the commercial and strategic (excluding military) needs in the coming ten years is evaluated at 35 billion dollars, i.e. 3 to 4 billion dollars per year. This is compatible with a relatively **small** number of launch services providers in the world (no more than three) if we want to avoid a commercial war, which will be detrimental for everybody

(customers and suppliers). It is therefore necessary to seek international ventures to achieve this goal. This also requires from the launch industry a specific organization and adaptation to present a good service, with quality, continuity, reliability, flexibility and cost-effectiveness. Arianespace's suggestion is for an international approach with various levels from simple commercial agreements to ensure the continuity and flexibility of the services, up to a full cooperation if necessary.

Session 1

Strategic Issues: National Perspectives (European and American)

Session Chair:

K. Doetsch, Vice President, Programs, CSA, Canada

Partnership Between CNES and Industry : A New Market Oriented Approach

P. Clerc, Head of Partnership Division, Directorate of Industrial Relations and Subsidiaries, Centre national d'études spatiales (CNES), 2, Place Maurice Quentin, 75039 Paris Cedex 01, France

Abstract

CNES's 1996 Strategic Plan repositions the French space agency for a more active role as a partner to French industry. The maturity of the space industry and the integration of space into the mainstream of economic activity and budgetary constraints have forced CNES to rethink its role towards "the partnership" concept. The rationale for such a new policy is that CNES has to go beyond its role of an agency distibuting funds to industry for the development of goverment space programs. As a center of excellence, CNES is a center of expertise with a tremendous competence in space technology, and should act as a partner helping industry to be competitive in the international arena. This does not mean that CNES would bid for contracts against industry. Instead, the agency would offer its services in research and development to buttress industry's work on a given task. CNES can take technical risks and perform research and development work that would either be difficult for industry or non-profitable in the short term. Knowing the market, industry can seek the contracts.

The challenge for CNES is now to implement such a partnership policy which is flexible and open-minded but more demanding for its employees. CNES has to adapt its administrative procedures, its procurement rules and its intellectual property regime to be compatible with such a partnership approach.

1. Introduction

The strategic plan of CNES (1996) (Reference 1) is designed to revitalize exchanges between the CNES and other players on the space stage, be they institutional, industrial or users, on a partnership basis. In the past, the CNES has made experiments with several partnership schemes, but in specific situations and by somewhat empirical methods. The original feature in the present concept is its more deliberate and systematic approach: partnership becomes the central factor in the strategy of relations between the CNES and the space community as a whole. It will now be a permanent element in planning the Center's activities, with appropriate procedures aimed in particular at promoting its development while guaranteeing that treatment is transparent, rigorous and fair.

This new policy assumes a different approach by the CNES, more flexible and balanced, with less interventionism. It is currently being considered internally in detail so that the conditions of implementation can be defined. The fruits of this process will be a "partnership guide" to be presented to CNES partners at a symposium at the end of 1997.

The guide is being prepared by nine working groups divided into two categories: five groups are discussing relations with our partners - industry and large technical research bodies, scientific bodies, users of space facilities, defense and Europe - and four are examining legal and financial aspects of partnerships, the relevant investigation, selection and assessment procedures, enhancing the expertise of CNES personnel through partnerships, and how the implementation of this policy is to be monitored.

At the time of writing, the groups are halfway through their work; this paper expresses the author's personal views, and does not claim to prejudge the conclusions which will be drawn from the current discussions. The text which follows deals mainly with industrial partnership. It outlines the motivations and benefits of partnership, and defines it and the parties involved. It describes a few current or planned partnership experiments. Finally, it gives the first principles for implementing such a policy.

2. The Motivations and Objectives of Partnership

2.1 To Adapt to Developments in the Space Environment

One of the CNES's first major tasks when it was set up in 1962 was to build a national industry in order to achieve the government's ambitions for independent access to space. In this case the national space agency acted as a client. Since then the space industry has developed, has diversified its areas of skill, and has successfully faced the "rules of play" of the market and of international competition. In addition, the new geopolitical order after the end of the Cold War made the budgetary context more difficult for the space sector, which had hitherto been fairly well protected.

Because of all this, the client-supplier relationship between the CNES and the space industry now seems outdated, though it made possible the creation of today's strong industry. The latter now needs a partner providing support rather than a client who cares little about its industrial and commercial strategy. At the same time, the needs of the users of space techniques and data have changed, and are no longer necessarily expressed via the CNES but directly on the market. Finally, government programs and budgets no longer provide the industry with sufficient outlets, and it is not even possible to meet the technological requirements generated by the market and commercial applications.

All these developments led the CNES to examine what part it should play in this new context, and to suggest new types of relationship designed to revitalize its exchanges with the space community and users.

2.2 To Revitalize Technological Research

The CNES must revitalize its basic technical research which, in the long term, is essential in order to preserve the technological ranking of French space products and services. In this respect, partnership can stimulate innovation by directing research towards the fields most likely to provide future outlets on the market. The CNES can also share with non-space partners its research costs in common generic technologies, such as electronic components and aerodynamics.

2.3 Strengthening the Competitiveness of the French Space Industry

To give French industry competitive advantages, and to promote exports. Partnership is an appropriate framework to provide a more effective support to French industry competitiveness, without affecting fair competition, in particular by promoting common basic research, sharing the development costs, facilitating technology transfers, or encouraging standardization.

To protect the diversity of the industrial fabric. It is in the general interest that CNES should help to strenghten a competitive and innovative industrial sector by preserving a balance between the major prime contractors capable of meeting world competition, the equipment manufacturers with unique expertise sustained by a critical mass of business, and a network of innovative small and medium-sized companies creating jobs. Partnership is an opportunity for the CNES to rediversify its relations with the industrial fabric as a whole, and not only with major prime contractors.

2.4 To Improve Dialogue with Partners

Like other specialist public research bodies acting in a single field, such as the Centre National des Etudes de Télécommunications (CNET), the CNES has not escaped a natural tendency to turn in on itself. There is no longer any reason for this isolation, now that space technologies are less and less specific, and activities performed thanks to space are, from the user's viewpoint, only one constituent in a more comprehensive service (such as the integration of terrestrial and space telecommunications with the information-based society,

or of space remote sensing with mapping and Geographical Information Systems).

To ensure the optimum use of state funding for the space sector, the CNES must cooperate better with its public partners and with industry, taking the socio-economic dimension into consideration more systematically. In a more general way, the CNES must encourage new and more balanced ways of exchange with its environment in order to develop comparisons between different technical cultures, which are a source of mutual enrichment.

2.5 To Disseminate and Enhance the Center's Skills

The CNES possesses or centralizes a remarkable collection of knowledge, technologies, expertise and material, financial and human resources. Its duty is to draw profit from these assets, in the general interest.

The advantage of partnership is that it facilitates the transfer of skills to industry so that it can meet the competitive market demand, while providing the CNES with a fair return, such as useful feedback for proposing or carrying out future programs, maintaining advanced expertise, and royalties or savings for the national budget.

2.6 To Promote and Enhance Space Techniques in Industry and Among Users

The CNES must give fresh impetus to its enhancement policy. The partnership structure, which allows exchanges of staff and of their know-how, promotes the success of technology transfers to the space industry and also to other industries. New forms of partnership must be discussed with the CNES subsidiaries concerned and other streamlined structures.

The objective of partnership with users will be to facilitate the emergence of new commercial applications and to increase the space sector's contribution to services in the public or general economic interest, for example the environment and meteorology.

Such partnerships involve both end users and institutional or private intermediaries using space facilities to meet commercial requirements or to perform tasks in the general interest. They mainly concern existing or emerging users of products and services for observing the Earth, collecting data, position location or telecommunications, in a broader context of integrating services and networks with the development of the information market.

3. Definition

The working groups' first ideas have produced a generic definition of partnership which can be expressed as follows: **partnership is the pooling of various resources (financial, technical and human) for the purpose of attaining a particular objective, providing each party with satisfactory returns, which may be of different types depending on the partners involved**: an economic or financial return, an industrial return, feedback of experience, etc.. Partnership must thus aim at mobilizing entities of different status, goals, trades or size (the public and private sectors, big industrial groups, smaller companies, universities, laboratories, etc.) towards the same end. Rather than simply adding up similar resources, as in conventional cooperation, partnership is more interested in synergy and new spin-off, and assumes that the partners complement one another, each making a substantial contribution to achieve the common objective.

4. The Players

The CNES's objective is to redefine a more consistent, fair and open network of relations with its environment. Here we will do no more than recall the CNES's principal partners and the frameworks of existing or future relations.

4.1 Industry

Partnership with industry is the major item in the CNES's new policy. This may involve upstream development of space equipment and architecture as far as qualification. The CNES will provide support essentially in the pre-competitive or pre-commercial stage ("critical" basic or upstream technological research, normalization, standardization, R&D support) which is best suited to the Center's business. Such partnership may concern projects for new launchers, mini-, micro- or nano-satellites, constellations, telecommunications, remote sensing, positioning services, etc.

The main features of this partnership with industry could be:

- Exchanges of resources, skills and technologies;
- Fair sharing of risks, responsibilities, costs and profits of any kind between the partners;
- Efficient matching of the skills and resources contributed;
- Fair intellectual property rights which reward the investments and risks incurred by the companies involved without excluding the possibility of

licenses, on fair and reasonable terms, to the rest of the country's space or non-space industry;
- Openness to everyone in industry: prime contractors, equipment manufacturers, sub-contractors, and smaller companies in the space or other sectors.

4.2 Public Technical Research Bodies

With a view to optimizing public investment in space research and science, the CNES and other government-owned bodies concerned (such as the Centre National de la Recherche Scientifique - CNRS, or Météo France), must cooperate more by drawing profit from complementary know-how and, as far as possible, avoiding duplication of resources and actions. For this purpose, a new type of partnership with each of these organizations should be considered in detail.

4.3 Defense

Since the mid-eighties the CNES has been an efficient and valued partner of the defense community; on behalf of the Direction Générale pour l'Armement (DGA) it participated in state sponsorship of Hélios 1 by optimizing synergy with the civilian Earth-observation program, SPOT. It also provided technical expertise of the Syracuse space component on Télécom 1 and 2. The CNES is a member of the space coordination group (GCE) chaired by the army chief of staff (EMA), and it contributes to drawing up the military pluriannual space plan (PPSM).

The objective of such partnership is to systematize synergy with defense in the development of space projects, with the aim of implementing a strategic, dual-purpose space program, which satisfies both civilian and military users and makes the best possible use of national resources spent on space and technological research.

4.4 Europe

This European partnership involves not only the ESA and its establishments, with which new forms of cooperation and program management are foreseeable (joint program teams, delegation of tasks, bilateral ESA/Member State projects, etc.), but also Member States and their industries with which the CNES wishes to create or re-establish bilateral or multilateral ties. Cooperation with the European Union will increase, particularly in basic

research and development (technologies not specific to the space field to be developed jointly, linking the CNES's medium-term planning with the Commission's framework program for research and development), in Earth observation (Vegetation, pilot projects, the Center for Earth Observation), satellite navigation (GNSS 1 and 2) and the information highways (the European Community's Advanced Communications Technologies and Services program - ACTS). On the institutional level such partnerships could explore Articles 130 K and L of the amended Treaty of Rome that, respectively, authorize "complementary programs" and participation to national programs.

5. A Few Current or Planned Partnership Experiences

5.1 Proteus - Jason

Proteus is one of the precursors of the CNES's new partnership policy. This system was chosen in the negotiations which followed a classic call for tenders issued by the CNES for the development of a low-orbit multi-mission platform, in particular for scientific, Earth observation and telecommunications applications. The draft agreement concluded with Aerospatiale, the partner , provides for equal shares in the development of the platform and its qualification up to delivery in connection with the first application, Jason 1, following the CNES-NASA Topex-Poseidon mission.

A joint project team has been working at the CNES facilities in Toulouse for three and a half years. Aerospatiale has undertaken to reimburse the CNES for providing these facilities and personnel, from a given number of sales after Jason 1.

The partners plan to promote the use and sale of Proteus platforms for both institutional and commercial markets, in particular for export, so that Proteus becomes a reference standard for this range of satellites.

There is a strict ceiling on the cost of recurrent platforms and their specific adaptations, to ensure that they are competitive, particularly toward international competition. The partners have set up a joint management committee which will be specially responsible for monitoring joint commitments and any changes in them. As regards third parties and competition, it is intended for the platform to be available for sale or production under a non-exclusive license by any manufacturer, on fair terms.

5.2 Vegetation 1 and 2

Vegetation is an instrument designed to be carried on SPOT 4 for observing and monitoring agricultural and forest vegetation. It is the first space instrument in France and Europe developed with joint financing from the European Community (EC) as part of a shared-cost operation under the outline program for technological research and development.

Although this partnership is innovative in its new relationship with the EC and users, in its industrial implementation it is fairly conventional. As prime contractor for the development of the instrument, the CNES has appointed Aerospatiale, which is not a member of the consortium under contract with the EC. The agreement on operation, to which the EC makes no financial contribution, appoints Spot Image as the leader company for distributing Vegetation data.

Vegetation 2 comes within the exclusive procedures inaugurated when the fourth Framework Program for Research and Technological Development started. A call for tenders was issued under the "Space" sub-heading of the "Environment and Climate" topic. In early 1997, a tender was sent to the Commission by a consortium including not only the present institutional members (CNES, SNSB, ASI, SSTC), but also industrial partners such as Aerospatiale, providing contributions in kind for the production of the instrument, and Spot Image, using its data-distribution network and know-how. The result of this tender is not known at present.

5.3 Skybridge

Skybridge, originally known as Sativod, is a world satellite-communications system (64 in a nominal constellation, in an orbit at approximately 1500 km) providing broad-band access for multimedia services. This system could be an outlet for a derivative of the Proteus platform mentioned earlier. The CNES also considers opportunities in studies of a control system for the constellation (orbiting and station keeping), which it could perform for the prime contractor, Alcatel. The conditions in which the CNES could participate in Skybridge have not yet been defined.

5.4 Others

Development of a micro-satellite or nano-satellite family could also be realised in a partnership between CNES and small and medium-sized companies.

6. Conclusion: Principles of Implementation

The working groups have stressed the importance of harmonizing the rules for partnership with the CNES's status (Reference 2) as a government-owned industrial and commercial organization operating in a particular way, in the general interest, and obliged to comply with "rules of play" on competition, particularly as regards government aids.

Management of the partnership, which is based on principles of fairness and transparency, must be the subject of a long-term agreement, even if it is not formalized by any specific text. The agreement may take various forms, such as a draft agreement, a consortium, economic interest group, public interest group, or a trading or non-trading company. The concept of partnership, however, cannot be a conventional relationship like that between a customer and a supplier, which generally comes under the heading of public procurement, or a shareholder and a company, which is a relationship of authority.

As regards the CNES's partners, all the groups drew attention to a number of guiding principles specific to the forming of a partnership. From industry's viewpoint, for example, partnership must be rationalized in the area of upstream technical research and partnerships must be diversified, in particular through greater involvement of equipment manufacturers and small companies in such upstream research and in projects, and by turning to advantage potential spin-off outside the space sector. Concerning scientific organizations, the CNES must aim to set up partnerships of limited duration, without excessive formalism so as not to discourage individual initiatives and a rapid start to projects. With regard to users of space facilities, they should be involved more in defining and implementing projects, particularly on the financial side. For defense, existing coordination structures should be adapted to changes in the DGA, crucial technological fields for the future of the civilian and military space industry should be identified, and France's representation in international authorities in the field of armaments should be organized jointly. Finally, partnership with Europe should take into consideration not only the European Space Agency (ESA) and its Member States but also other entities such as the European Union. For the former, it should be based on a

change in relations with the ESA through stronger proposals by the CNES and frequent attempts to involve a few countries in a project, and for the latter on the means of consolidating the position of space activities in Community affairs.

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How National Space Activities May Be Integrated Into The Economic Mainstream

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Abstract

The paper considers fields of space business that expand and therefore are of importance for the national economy. For these fields, national space agencies must foster both the necessary technologies as well as complementary capabilities. To this end, new forms of private-public partnership will be necessary. The expected benefits for the national economy will then depend on how we succeed in shaping this specific partnership. For more than 30 years European governments have jointly pursued common space programmes. These have helped in developing a vast spectrum of competence with particular emphasis on space science and space related technologies. But so far they have not resulted in the deployment of an independent and basically competitive industry in Europe sustaining itself on the commercial success on free markets. European governments have repeatedly expressed a strong commitment to the International Space Station. Now they are aware of the many economic prospects emerging from the free consumer markets and the resulting demands for new space related goods and services. The forecasted demand pull, in particular, offers new opportunities for the economy. Moreover it may also have an impact on the role of space for European defence and security issues; in advanced aerial and ground transportation opportunities through space-borne navigation or positioning; in weather forecasting; in international policy formulation for the protection the natural environment and agriculture; finally, in the progress of basic knowledge, which includes the support of fundamental science as well as for scientific training and education. Consequently, DARA and its partners are forced to develop clear views on such issues as:

- The products and end-to-end services from Europe that will underpin and permanently sustain Europe's industrial competence in space;
- Economies of scale and resulting opportunities for European industries on the global stage;
- The commercial fields where European industry has proven the potential to provide high performance space components and systems, in adequate numbers and at a globally affordable price;
- The intra-European competitiveness in the space business and the necessity to redress the European "juste retour" mechanism to an appropriate level;
- The principle of reciprocity when accessing the expanding markets in Asia and the US; and
- The availability and importance of risk and venture capital for enabling innovative space-borne services of the future.

1. The Economic Mainstream

As things stand today, we are convinced that what is generally termed the "Information Society" is at hand. Its prime feature is the availability at any time, to nearly everybody and individually relevant, of a wealth of real-time information. To really come true, information acquisition, processing,

distribution and transmission systems and capabilities are needed, far beyond what is presently available. No doubt, space systems, means and technologies will considerably contribute to this end. Once coming into being, we expect the demand to be such that an enlarged business, on a purely commercial basis, will result; a business which will embrace all sorts of space related services, ground installations, launchers, satellites, platforms, etc... (see Figure 1).

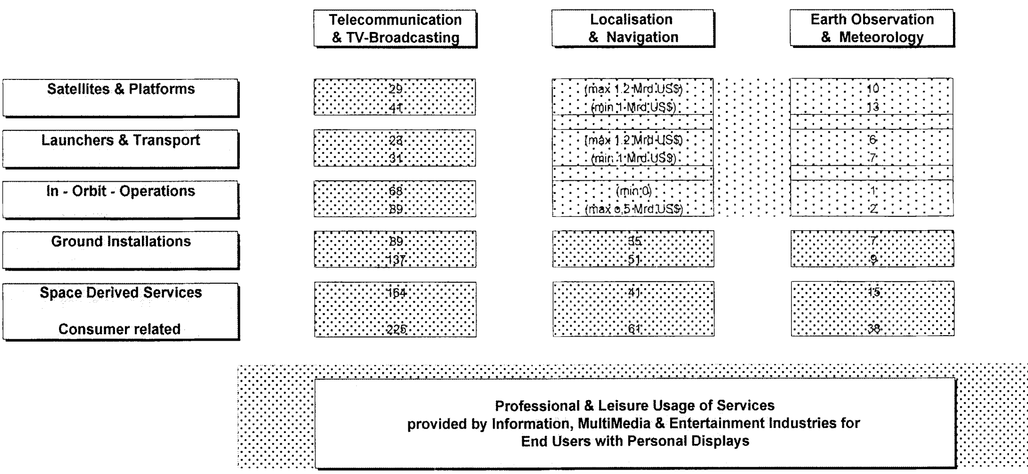
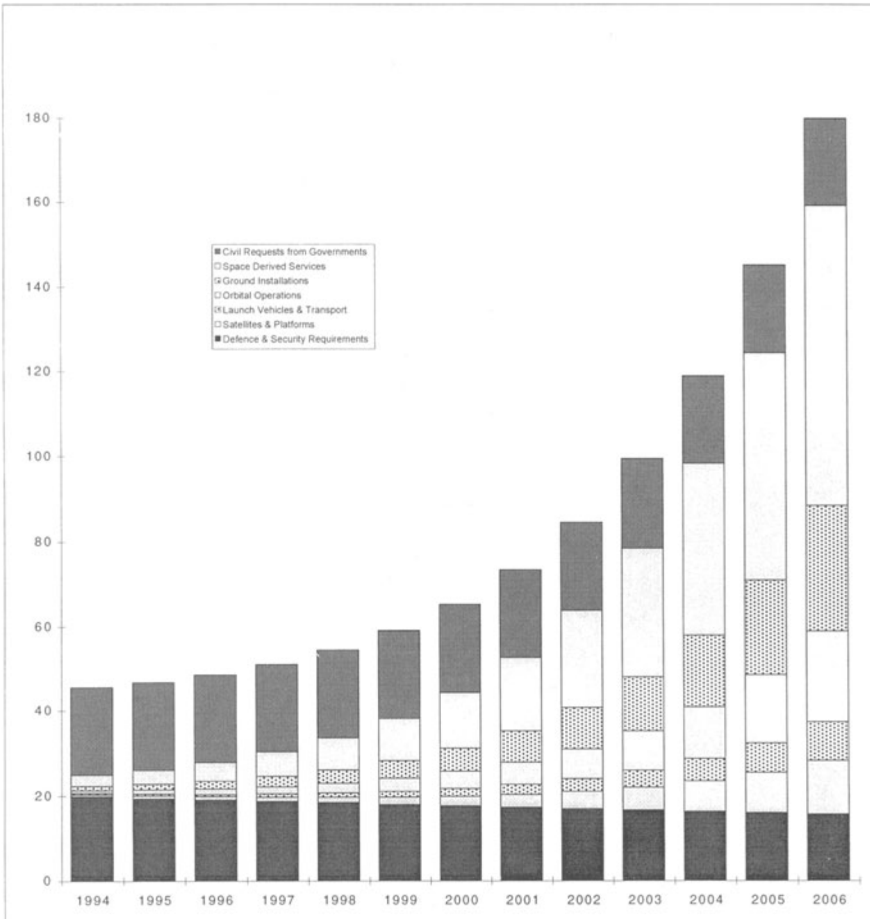


Figure 1. "World Space Markets 1996 - 2006"
Industrial Turnover: US $530 - 760 billion

This chart was produced after a recent meeting when DARA called together the heads of major German space companies as well as experts (including some from the French consultancy, Euroconsult). The objective was to discuss the prospects of future space markets. No doubt, if pertinent forecasts prove to be realistic, the forthcoming development will turn upside down the familiar relations between governmental civil space activities, space related national security activities and free market activities (see Figure 2).



	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	
Defence & Security Requirements	20	19	19	19	18	18	17	17	17	16	16	16	15	
Free Consumer Markets:														100%
Satellites & Platforms	0.4	0.6	0.8	1.0	1.3	1.8	2.3	3.1	4	5	7	9	13	8.75%
Launch Vehicles & Transport	0.3	0.4	0.6	0.7	1.0	1.3	1.7	2.3	3	4	5	7	9	6.40%
Orbital Operations	0.8	1.0	1.3	1.7	2.3	3.0	4.0	5.3	7	9	12	16	22	15.01%
Ground Installations	1.0	1.4	1.8	2.4	3.2	4.2	5.5	7.3	10	13	17	22	30	20.63%
Space Derived Services	2.5	3.3	4.3	5.7	7.5	10	13	17	23	31	40	53	71	49.22%
Civil Requests from Governments	21	21	21	21	21	21	21	21	21	21	21	21	21	
Totals	46	47	49	51	54	59	65	73	84	99	119	145	180	
32% Wirtsch. Wachstumsfaktoren	1.00	1.32	1.75	2.31	3.06	4.05	5.36	7.09	9.37	12.40	16.40	21.70	28.70	
2 % Vtg. Schrumpfungsfaktor (1990/!	1.00	0.98	0.96	0.94	0.92	0.90	0.89	0.87	0.85	0.83	0.82	0.80	0.78	

Figure 2. Prospects for global space business
(in US $ billion)

2. The Goals

No-one can tell with any precision today how fast this development will proceed. In fact, this question is to us of only secondary importance; there may be deviations from the forecast by a factor of two upwards or downwards. Vital for us is the obligation to see to it that the German space industry - or the European one, for that matter - will participate in the development and, in particular, in the ensuing fields of new business. Certainly, this will not come about by itself. It rather will need state encouragement and support. To this end we need appropriate readjustments.

To understand how these adjustments can be made at the agency's level we have to go back to our basic goals. In principle, agencies are to serve the tax paying public. The taxpayers' interest in space is in yielding return from:

- Technical and scientific progress,
- Economic growth,
- Self sustained employment, and
- A secured well-being in a healthy environment.

With this basic understanding in mind, the government of the German Federal Republic is now drafting a new space strategy. The draft addresses two key points: a reassurance of Germany's engagement in the International Space Station, and the major importance attributed to the deployment of new space applications responding to self-sustaining economic and public demands.

Indeed, major emphasis is given to an economically reasonable expansion of space business as a means to induce a positive impact on Germany's national economy. Accordingly DARA is challenged to identify the prospects for space related applications which promise a sizeable economic and/or public return. The above mentioned demand enroute to the information society offers such key prospects.

3. The Competitive Environment

To understand the German or the European opportunities, we have to compare our specific strengths and qualities with those of our competitors or partners. Much can be learned by comparing the performance of the major space faring nations (see Figure 3). The chart visualises the excellence of the US since the Soviet Union has fallen apart. It also makes clear that space for some time

to come will continue to be dominated by the US, Europe and Japan exclusively. (see Figure 4).

Nation	GNP/capita {US-$}	GNP {Mrd US-$}	GNP relative	Pop. {Mio}	R&D/ GNP	Space Spending {Mio. US-$}	Space Spending relative	Civil S. relative	Defence S. relative	Space personnel
CH	43,233	293	1.30%	7	2.68%	90	0.24%	0.24%	0.00%	500
N	33,535	158	0.69%	4	1.74%	40	0.11%	0.11%	0.00%	380
DK	33,144	174	0.77%	5	1.79%	40	0.11%	0.11%	0.00%	350
D	29,542	2,354	10.46%	82	2.33%	1,050	2.85%	2.25%	0.60%	6,800
A	28,997	228	1.01%	8	1.53%	45	0.12%	0.12%	0.00%	260
B	26,556	264	1.17%	10	1.60%	210	0.57%	0.56%	0.01%	1,150
F	26,445	1,545	6.87%	58	2.34%	2,580	7.01%	4.91%	2.10%	16,800
S	26,096	253	1.12%	9	3.26%	100	0.27%	0.27%	0.00%	1,050
NL	25,597	393	1.74%	15	2.05%	120	0.33%	0.33%	0.00%	750
FIN	24,463	123	0.55%	5	2.35%	30	0.08%	0.08%	0.00%	380
I	18,983	1,204	5.35%	57	1.14%	640	1.74%	1.60%	0.13%	5,800
UK	18,777	1,140	5.07%	59	2.05%	490	1.33%	0.80%	0.53%	4,000
IRL	17,964	69	0.31%	4	1.41%	5	0.01%	0.01%	0.00%	60
E	14,272	585	2.60%	39	0.85%	160	0.43%	0.43%	0.00%	1,250
LUX		17		0.4						
	Europe contributes		*39.0%*	*to the joint*		*GNP and*	*15%*	*to taxpayers' spending for space*		
US	28,435	7,263	32.28%	263	2.59%	26,500	71.97%	35.10%	36.87%	123,000
	The US contribute		*32.3%*	*to the joint*		*GNP and*	*72%*	*to taxpayers' spending for space*		
JAP	40,726	4,578	20.35%	125	2.84%	2,220	6.03%	6.03%	0.00%	13,200
	Japan contributes		*20.3%*	*to the joint*		*GNP and*	*6%*	*to taxpayers' spending for space*		
CDN	18,915	576	2.57%	29	1.62%	272	0.74%	0.74%	0.00%	4,300
RUS	2,650	393	1.75%	148		630	1.71%	1.25%	0.46%	124,000
CHINA	530	631	2.81%	1,191		1,300	3.53%	1.36%	2.17%	124,000
INDIA	310	283	1.26%	914		300	0.81%	0.36%	0.45%	21,000
	R.o.W. contributes		*8.4%*	*to the joint*		*GNP and*	*7%*	*to taxpayers' spending for space*		
Totals	**7,500**	**22,500**	**100%**	**3,000**		**36,822**	**100%**	**57%**	**43%**	**450,000**

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Figure 3. "Performance of space faring nations"

	GNP	R&D expenditure	Space expenditure	Industrial Space Sales
USA	32%	35%	72%	76%
Europa	39%	32%	15%	13%
Japan	20%	23%	6%	6%
R.o.W.	8%	10%	7%	5%

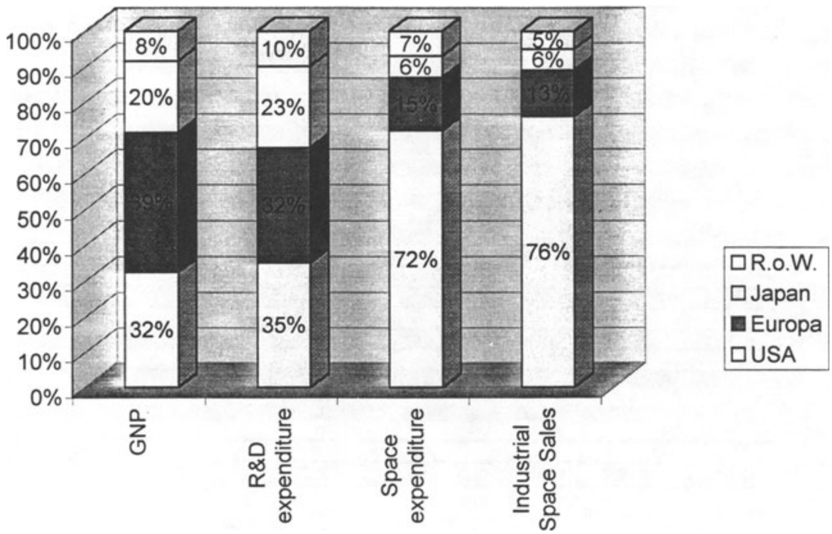

Figure 4: Performance within the Triad

In this global environment, Germany can be successful in space only if it concentrates its ambitions. Germany can make remarkable contributions only by investing the available resources and energies on a small number of the possible fields. From the comparison we conclude that the selection must result in not more than 3% of all possible fields. If we selected a larger number of fields Germany would waste most of its scarce resources in mediocrity. However, it is needless to say that within the selected fields both industry and government must be determined to excel over the competitors and strive to be second-to-none.

To ensure success, the expensive challenge of established competitors must be avoided, at least in the early (embryonic) phases. Thus both industry and government must study the options of all possible competitors with the utmost care. In addition, they must pay specific attention to such issues as:

- The risks and path dependencies of evolution in space related high-tech areas,
- The conditions for entering space markets associated with high initial costs,
- The economies of scale in the production of space related goods and services, etc.

By aiming at answering these questions we expect to obtain clear views on the advantages and the disadvantages of open competition as compared to labour sharing, co-operative partnerships.

4. The Perception of Opportunities

The crucial question is: on which fields should we focus? If we posed that question to all industrial companies we might get as many answers as companies. However, in our country the number of companies which really participate in some global leadership is limited. Most of these companies have accumulated proven experience in growth and in expanding their corporate business. Many of these have specialised in specific niches of the global business, and within these niches they have demonstrated strong innovative capabilities. They rarely possess a complete system competence but often are flexible enough to seize emerging opportunities quickly.

The leaders of these companies very often have developed a good sense for what is realistic and feasible.

5. The Approach

Starting with the perceptions of these able businessmen, the agency has established a process of shaping bottom-up mechanisms to steer public-private partnerships for appropriately identified fields and specific niches of the space business, with the objective to augment the national return. In spite of the fact that by their nature public and private interests seldom match, there is a common objective which can be expressed as the augmentation of the national share in an identified field or niche of global space business. This objective does not exclude foreign companies from participating. On the contrary, we

experience that the complexity of most new business often asks for a vaster spectrum of competence than that which could be provided nationally at an affordable price. Therefore the approach will eventually also induce an improved sharing of labour within international co-operation by including other leading companies from Europe, in particular, but also from the US or Japan.

Our approach is by no means discriminatory. It is challenging competitiveness and progress for the benefit of space business in general. For Germany it has some additional advantages which can be expressed in terms of technical and scientific progress, economic growth, self sustained employment and a secured well-being in a healthy environment.

How to Encourage Industry to Reach New Space Markets and to Develop Space Commercialisation

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Abstract

The ESA Office of Space Commercialisation was created in 1986 with the objective to define and to develop, in cooperation with the ESA Programme Directorates, a strategy to promote the industrial utilisation of space and to facilitate the transfer of space technologies and systems to the private sector. The Agency's role is not in itself a commercial one, but rather one of promoting the development of space commercialisation. To achieve this, the Office is conducting several studies with a view to identifying new space markets and to establishing a permanent dialogue with non-space companies. As the main activity of the Office, the ESA Technology Transfer Programme aims at promoting the widest use of space technology outside the aerospace sector (spin-off), and, reversely, encouraging the use of the best technology of the market through partnerships with non-space industry (spin-in). To this end, ESA has set up a network of technology transfer brokers represented in all the 14 ESA Member States and in Canada. During the last two years, this network has developed contacts, amongst others, with the automotive, the medical, the off-shore and the textile industries. For each of these targeted markets, the technology transfer brokers have identified several needs and have performed matching research for space technology or know-how which could potentially respond to these needs.

This paper gives some examples of successful technology transfers from space to non-space sectors; it also describes the methodology developed by ESA and its network to encourage industries to reach these new markets and to increase their participation in the space commercialisation process.

1. Background

It is generally agreed that the European space community is today facing a turning point: the sudden need, anticipated by some but not all, to steer away from a familiar safe course and negotiate a fast and hazardous stretch which will lead to renewed stability. Whether it succeeds in doing so will very much depend on the skills of the driver and navigator, and the quality of the vehicle. The European Space Agency's manoeuvrability can be rated in terms of its relations with the European space industry, but also in terms of the strength of its political conviction, founded on a geopolitical and economic analysis of the necessary evolution of its role against a background of the pervading integration of space technology into the world economy.

The strengths of its performance to date lie in the ability it has shown to initiate and manage the development of important, effective technologies and also to carry through programmes of unfailing quality. Its key political asset,

which sometimes gives rise to controversy because it is misunderstood, is its ability to gather in funding from its Member States, underwritten by the fair industrial return concept. It is thanks to the fair return approach that the space sector has enjoyed genuine European preference, which is no longer to be found elsewhere. It might even be suggested that the fair return rule is one of the last bastions of a space policy that gives priority to Europe.

In response to the ultra-rapid development of commercial uses of space and the globalisation of systems and markets, industrial giants are being created by takeovers and mergers. The restructured industry that is taking shape as a result can survive and prosper only if it is supported. The fundamental question that arises here is whether government agencies, habitually slow to react, are going to be able to adapt to the new situation.

The European Space Agency has succeeded in ensuring that its founding nations acquired the space technology necessary to develop technological and scientific capabilities in a number of well-known key areas: telecommunications, Earth observation, launchers, the human presence in space and space science. Its role now consists in helping the industry towards whose creation it contributed to maintain its standards of excellence and secure its future. The Agency is no longer the space industry's main market. The survival of an important sector of the European economy - the space sector - depends on markets that are largely outside the Agency. Very large markets are developing for new services delivered to end-users, often very remote from the traditional "space community", and the space segment is no longer playing a predominant role in these markets. With the new space applications that are emerging, practically all sectors of the economy are affected or soon will be, and this includes the mass consumer market. An obvious case in point is the development of the information society, but other applications sectors are involved as well, such as Earth observation, of which it may be argued that insufficient effort has been put into developing the full range of value-added services and downstream industries and services.

The characteristic feature of this context is the expansion in the number of players. This has been brought about by the historical development of space applications, the promotional role played by the European Union or other European organisations, the new economic challenges, and the consequent spread of possible sources of finance and multiplicity of options and constraints. Another feature is the importance of giving rein to initiative on the part of industry, whose vitality and manoeuvrability ought to enable it to adapt as

long as it can be given the necessary assistance, in an appropriate context enabling partners to agree a basis for sharing tasks, risks and benefits.

This new situation has been clearly understood by the ministers responsible for space in Europe. On 5 March 1997 they approved a resolution on the Agency's industrial policy in which the emphasis was on improving the competitiveness of the European space industry and making the Agency's programmes more efficient to that end. The ministers recommended opening up the Agency to a form of partnership with the various players involved in commercial space applications, including the space industry itself. The make-up of such partnerships and the rules governing them are currently being examined. The aims are clear: to define the roles of the various players (agencies, space industry, operators, service companies, other European organisations, etc.) more clearly and to share risks and responsibilities according to what is at stake.

This calls for a more detailed analysis of the situation in Europe, an analysis to which all the Agency's Member States subscribe, so that it will inspire a renewal of the political commitment of those pioneering days which saw the creation of the space capability that now needs to be maintained. The mistake to be avoided in this analysis is to regard the space industry collectively as a homogeneous whole, since in reality it is diverse and subject to restructuring and other changes, the reasons behind which are sometimes far removed from space interests as such. Indeed, the same ministerial resolution envisages differential treatment of the companies concerned according to their roles, their size and the programmes in which they are engaged. This will be done in close symbiosis with industry, paying careful attention to its difficulties and concerns.

In general terms, the key to renewing the European Space Agency's industrial policy lies in reliance on the initiative of industry, based on its own understanding of commercial prospects, underpinned by the political players' analysis of their support policies and the reasons behind them. This means that industry, having decided to play its part in the expected economic developments, must make its own analysis and determine its own policy for preparation and action.

2. Today's Situation

Looking back over the development of space activities in Europe, it is clear that, for historical reasons having to do with national telecommunications monopolies and delegations' preference for the uses of applications programmes

developed by the Agency to be conducted nationally, the space segment has long been regarded as the primary focus of industrial cooperation or competition, which the Agency has often encouraged. It is only recently that the diversification of services and the need to adapt them to specific user requirements have led to the unavoidable conclusion that a service has to be a complete package and the industrial arrangements for creating and delivering it have to be based on stable agreements between companies. The truth of this is especially clear in the case of constellations of satellites requiring production in large series, which has hitherto been beyond the scope of European programmes. Hence the emergence of stable industrial agreements designed to improve the investment/output ratio, which may be regarded as a reasonable measure of a space product's competitiveness. The ESA/CNES/Arianespace relationship is still regarded as the paradigm of competitiveness and "efficient" industrial organisation. It is nevertheless open to challenge in that it may be asked whether the importance attributed to "government" projects, such as Hermes, has not had a distorting effect, preventing a proper appreciation of the priority aim of winning markets. This should prompt a serious reassessment of the formula for striking the right balance between political objectives and industry's commercial imperatives.

There is also a need to move on from the approach adopted in the early 1970's to the conception of new programmes. In the absence of identifiable commercial users, new applications were designed for scientific users. But once programmes had become operational, potential "paying customers" found that the data offered, while of the highest quality, bore no relation to their real needs, in terms of the products themselves, their prices or their availability. This is in fact a problem common to all space agencies, which are having to reduce their financial support and look to industry for "small but smart" options, whereas what they really need to do is listen to users and provide the services which they are prepared to pay for, in whole or in part.

There are plenty of lessons to be learnt. It takes humility to heed them and draw pragmatic conclusions. There are customers to be found, as long as they are offered what they are looking for.

An extreme example is the commercialisation of prospective products from the International Space Station. The challenge of finding private users of such products was taken up by NASA a few years ago by opening Centres for the Commercial Development of Space. Unfortunately, that initiative was scrapped before it had had time to show results.

In Europe, RADIUS (Research Associations for the Development of the Industrial Use of Space) is an initiative on similar lines, but attuned to European culture and needs. Its experience has demonstrated that large companies with substantial research programmes are prepared to pay for services using microgravity or remote sensing, and that an approach based on helping to define users' real needs can be very effective. This holds out prospects for the faster development of markets that have tended to stagnate, such as remote sensing. In this area as elsewhere, well founded and clearly defined partnerships, involving agencies, users, operators, value-added service providers and manufacturers, could bring about an acceleration in the development of markets.

3. Conclusions

To conclude, it should be emphasised that, while the scope for commercial development of space is vast and complex, the scene is set for rapid expansion on the basis of sound cooperation in which the challenges to be met have been correctly identified and the means of doing so put in place. Industry must therefore identify its commercial goals and, having done so, reopen detailed dialogue with all interested parties and then propose terms for new arrangements for cooperating with the Agency. The Agency for its part is giving active consideration to setting up a "space utilisations monitoring unit", which would improve and refine the gathering of information on the situation on developing markets, an activity which has hitherto lacked coordination, being scattered across the Agency's various directorates. It needs to build on the period that has been spent acquiring expertise by promoting and developing the use of space.

We find ourselves in the paradoxical situation of a small or medium-size business which has developed an excellent new technology but lacks the know-how to promote and market it, achieving the volume of sales that will bring expansion for the company.

The Agency's prime asset is its political platform; its difficulties are those of an enterprise that has become set in its ways, resting on its laurels and reluctant to change. Let us trust that, when they next meet in our Council, the ministers will take the measure of the situation and open up the Agency to the great challenges of the second generation, enabling European space community to negotiate that turning point.

Government as a Customer for New Space Services

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Abstract

The roles of government, at both national and European levels, have always included those of regulator, sponsor of scientific activities in space, and provider of pump priming funds for new applications. This paper discusses an often overlooked role of government - that of customer. Examples of the influence of governments purchases on the shape of the space market are provided in Earth observation, satellite communications and navigation.

The conclusion is that governments must consider the market-shaping power inherent in their role as customers for space services. UK industry, through its trade association, the United Kingdom Industrial Space Committee (UKISC), has published a paper, 'Making our Space Industry Competitive', detailing how these principles could be applied to ESA's programmes; they could also be applied at national level, and to EUMETSAT, the European Commission, the Western European Union and other public sector users of space services.

1. Introduction

In most countries, governments encourage industry to become competitive on the world market. Policies to support this objective usually concentrate on the supply side of the market, for example in the form of R&D support to the industry in question. This paper looks at the same objective from the demand side by examining what governments can do to foster stronger home markets for their space industries and, in particular, what effect government purchasing power can have on the shape of that market.

2. Role of Government

Before discussing government's role as customer, it will be helpful to review its other roles in space.

Government as Regulator. The most universal influence of the regulators is in defining the uses of the radio spectrum. The trend towards auctioning of spectrum in several countries should not disguise the fact that the allocation of services to particular parts of the spectrum can only be carried out by agreement between governments.

Other regulatory functions of government are also important. In the television sector, for example, regulators control the content of programmes both directly and indirectly. Direct regulation can take the form of restrictions on the source of programmes or on the spoken language used, as well as the more obvious technical regulation of the coding and modulation types to be used.

Indirect regulation takes many forms, including restrictions on advertising, on actors and on invasion of privacy.

Regulatory factors are also being felt in the satellite navigation domain. In order to be used as a sole means of navigation by commercial aircraft, satellite navigation systems will have to be certified by the relevant authorities.

In the Earth observation sector, government has always kept very tight regulatory control of developments. Governments determine data policy, which generally favours the idea that space data is a public service and therefore should be available at little or no cost to users, for example in satellite meteorology. Governments also restrict the resolution of pictures from space.

Government as sponsor of advanced technology. For many countries, the strongest motivation to invest in space technology is the position of space at the pinnacle of the added value pyramid - see Table 1.

Thus, as countries seek to move their industries further and further up the added value ladder, space is seen as a key step in that process.

Product	Added Value	Product (continued)	Added Value
Satellite	20,000	Semiconductor	100
Jet fighter	2,500	Submarine	45
Supercomputer	1,700	Colour television	16
Aero-engine	900	NC machine tool	11
Jumbo jet	350	Luxury motor car	10
Videocamera	280	Standard motor car	5
Mainframe computer	160	Cargo ship	1

Table 1. Relative added value (Reference 1)

Government as international negotiator. Governments define the environment within which space commerce operates through international trade agreements, for example to ensure fairness and reciprocity.

Another manifestation of this role is the existence of international organisations, such as INTELSAT, INMARSAT, EUTELSAT, EUMETSAT and the European Space Agency (ESA). These organisations are the creation of governments, and the role of industry in their activities is determined by the regulations agreed by governments at their inception.

Government as guardian. Space provides a means by which governments can fulfil their function as guardians of a nation's, and even of the planet's, environment, economy and security.

Other government roles. Governments continue to fund the use of space for research into the nature of our Universe.

The manned exploration of the solar system is another role for government. The increasing expense of this type of space activity in comparison with that of unmanned satellites has reduced its potential as a commercial space activity, thus reinforcing the need for public sector funding of programmes such as the International Space Station.

3. Influence of Government

From the above review of government's role, it is clear that governmental influence on space activities is enormous. World-wide, some 75% of all space activity remains under the control and funding of governments (Reference 2). In short, governmental actions shape the space industry.

In Europe, as in many other parts of the world, government's objective is to foster a competitive industry. Government-sponsored R&D has been one of the key forms of government influence in the past, and will continue to be important for some time to come. In Europe, however, the trend in government intervention is changing towards involvement in operational systems, for example by funding pilot projects.

A recent UK government policy statement on public sector procurement (Reference 3) makes the point that government's purchases for its own use are a powerful mechanism for shaping the industry supplying the products or services in question. This argument is not restricted to space systems, but applies across the board of public sector purchasing. In the next three sections, the importance of this principle for various space applications will be examined.

4. Government as Customer

4.1 Earth Observation

Even omitting military sales, the public sector is the leading customer for Earth observation data and services (Reference 4). The industry which

supplies the data and services is often criticised as being fragmented, but industry has to reflect the nature of the market it serves.

The public sector market in Europe for Earth observation data and services is currently divided among the individual countries. This fragmentation could be sharply reduced because much of the public sector use of the data is for the implementation of European Commission directives and regulations.

The monitoring of fraud under the set aside policy of the EC's common agricultural policy is an illustrative example. Each country buys data and interpretation services from industry to monitor the set aside policy. Worse still, these contracts with industry are placed a year at a time. The value of each contract is in the region of 500 kECU. Of this price, perhaps 100 to 200 kECU is for data, with about twice that amount for interpretation. The market has adapted to the demands of the clients, and the result is the emergence of about a dozen or so small to medium sized added value companies around Europe.

Imagine instead, if Europe (not each country) procured ten years of data and interpretation services at a time for this application: the resulting contract would amount to perhaps 50 MECU. The winning contractor would be able to invest in cost-effective technology which would provide value for money to Europe and would make the contractor competitive on the world market for such services. Furthermore, the steady and predictable level of data sales would facilitate the planning of satellite operators.

A more general version of this role for the EC has been proposed by a group of European industrialists, called the High Level Group (Reference 5). The proposal seeks to exploit the more widespread use by the EC of Earth observation data. Besides policing the set aside programme, the EC uses Earth observation data and services for many other agricultural monitoring purposes, for fishery management, for land use statistics and for environmental monitoring, to name but a few applications. Thus, the High Level Group proposed that the EC guarantee a certain level of Earth observation business to industry, which would enable industry to invest in a complete system, including both space and ground segments.

By acting as anchor tenant in this way, the EC would not only get better value for its own money, but would enable industry to create a market-oriented end-to-end system. The High Level Group then envisaged that at a later stage the EC's guarantee could be withdrawn, and the programme continue on purely

commercial grounds. Because of these two distinct stages towards the creation of a commercial market, the concept is known as the two step approach to commercialisation.

4.2 Satellite Navigation

The market for satellite navigation systems, services and equipment is heavily influenced by government. The satellites predominantly used for this application are owned by the USA and Russian governments - the GPS and GLONASS systems, respectively. The civilian market sector most committed to funding upgraded services is that of air traffic control, which in most countries is in the hands of government-owned organisations.

Facilities are now being developed in Europe, the USA and Japan which will enhance the information supplied by GPS and GLONASS, enabling satellite navigation to become a sole means navigation aid for aircraft in many phases of flight. In Europe, the air traffic control authorities have begun to exercise their influence as the eventual users of the system. The facilities, called the European Geostationary Navigation Overlay System (EGNOS), are being developed by ESA, but the representatives of the air traffic control authorities have advised ESA on changes to make to the specifications so that the system will comply with aviation needs.

It is still necessary for the users to create an organisational framework which will allow the system to be integrated into routine air traffic management operations. Steps are being taken to create that framework under the aegis of the EC and the European air traffic management organisation, Eurocontrol.

EGNOS is an example of how an R&D organisation can be used to develop a new space system, but guided by a public sector customer organisation. In principle this type of collaboration could also be used for the next likely step in satellite navigation, i.e. the development of a civilian space system to augment or replace GPS and GLONASS. Without the public sector customer involved in defining the programme, the eventual system risks being inappropriate for its intended use. In addition, involvement of the end customer in the development creates a sense of ownership of the system in the customer, thus ensuring a ready take up of the system by users.

4.3 Telecommunications/Broadcasting

The motivation for industry to invest in starting up new satellite communicatons systems is usually commercial. However, in the case of broadband communications, public information services have emerged in some American trials as a highly successfull application. Thus, broadband networks to provide the general public with information on government services may well be the critical application which underpins the start-up phase of these new systems. In order for that to be so, governments must wish to make the relevant information available to the general public. In the UK, this concept has become known as government.direct (Reference 6) and, if put into practice, would require substantial broadband network capacity on a national scale - something which satellites can provide more rapidly than any other medium.

Thus, even in the commercially advanced area of satellite communications, government's role as customer may prove to be vital in enabling new systems to become commercially viable.

5. Implications for European Organisations

5.1 European Space Agency

The examples in Section 4 illustrate how governments must consider the market-shaping power inherent in their role as customers for space services.

For the European Space Agency, fostering of industry's competitiveness is written into its convention. However, in recent years the implementation of that part of the ESA convention has often been interpreted as a demand to dilute the application of ESA's geographical return principle in the award of contracts. The need for ESA to promote a self sustaining customer/supplier relationship as a product of its programmes has tended to be overlooked.

The UK space trade association, UKISC, produced an analysis of possible ways to make ESA's procurements compatible with world market trends (Reference 7), with recommendations falling into four broad categories:

- Initiatives aimed directly at improving industry's global competitiveness
- Changes to the management of ESA's R&D programme to bring that programme more fully into line with world market needs
- Changes to procurement practices so that the products and services procured are compatible with world market trends

- Fostering of operational agencies as part of ESA's pre-operational programmes with a view to moving away from financing of the supply end of the value chain and instead to finance the user end, thus fostering a home market for European industry.

ESA is a key customer for Europe's space industry, and it is vital that the Agency's procurements reinforce industry's export initiatives.

5.2 European Commission

As noted in section 4.1, the European Commission is a major customer for Earth observation data and services, both directly and indirectly. Generally speaking, the Commission places more emphasis on its policy making role than on its role as a customer. The view of industry (Reference 5) is that the customer role is crucial, and the two step approach to moving towards a sensible customer/supplier relationship has been proposed as a way forward.

In telecommunications and broadcasting, the Commission often overlooks its buying power. The dissemination of information throughout the European community requires sophisticated networks and end user facilities. The Commission can use its own dissemination requirements as a mechanism for fostering the latest techniques, thus giving European industry a major home market for the latest products. Satellite systems and services for multimedia applications are an example of the type of systems which the Commission can sponsor, not as an R&D activity, but in direct support of its operational policies.

Individual nations have substantial differences in regulations for broadcasting and communications, e.g. in advertising, privacy and source of programmes. Thus the Commission is the only major customer which can foster multimedia applications on a continental scale - a key requirement if Europe's industry is to compete with its counterparts in America where the market is inherently continental in scope.

5.3 Other European Organisations

The potential for selling satellite meteorology products outside Europe emphasises the importance for EUMETSAT to give some thought to the influence of its procurement practices on European industry's export potential. Recent successes include the sale by MMS of a sounder to Brazil and by Logica of a ground processing facility in Japan.

The sale of military satellites outside Europe is a major potential market for European industry. This potential applies to both communications and surveillance systems. The Western European Union can assist with industry's export attempts by ensuring that the procurements of its interpretation centre in Torrejon are in line with industry's export aims.

6. Conclusions

Public sector organisations often overlook the influence which their purchases can have on the shape and abilities of the supply industry. A well structured home market can enable an industry to better tackle export opportunities.

If European industry is to succeed on the world export market, public sector organisations must play their part as intelligent customers. As the recent UK government White Paper put it (Reference 3, 7.5): The best contribution that [government] Departments can make, as customers, to the enhancement of the competitiveness of suppliers is to manage their own procurement intelligently and well. An important element of this will be to combine competition and co-operation in an optimum way.

The commercial space world has begun to follow the practice of customer/supplier partnership as the best way to achieve commercial success. Public sector bodies also must begin to enter a dialogue with suppliers in order to ensure that their power as customers enhances the suppliers' competitiveness, as well as providing better value for money.

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Combining Technical and Business Ingenuity to Create a Robust and Adaptable Marketplace that Anticipates, Meets and Exceeds Customer Needs

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Abstract

A NASA Task Force has conceived a provocative concept for a supply/demand framework that (1) supplies the Agency's strategic business units with commercial, reusable, cross-cutting products and services that appear unique, but are not, and (2) enables the business units, as paying customers, to demand "faster, better, cheaper" products and services for planning and conducting space activities. The concept provides for proactive matchmaking to benefit both the supplier and customer communities. Supplier benefit would be measured by the opening up of new markets, particularly for the non-traditional aerospace companies, with genuine cross-cutting product lines. Customer benefit would be measured by NASA's incentive to become smart buyers and influence the marketplace to provide products and services that anticipate, meet and even exceed their needs. Further, by acknowledging common functionality and similarities in requirements across the customer business units, NASA could disengage from the current practice of spending public funds for unnecessary duplications, such as building and buying unique products and services for similar functions.

The building and buying of products and services that appear unique, but are not, are achieved via the assembly of bona fide building blocks, derived from first principles. Engineering acumen is required to identify the right set of building blocks that can be assembled on customer demand. Entrepreneurial prowess is required for creating a commercial, reusable and cross-cutting supply chain. This paper describes the technical and business ingenuity employed to motivate NASA to participate in a market-driven supply/demand framework. Also discussed is the applicability of this framework for better integrating space activities into the economic mainstream.

1. Background

During 1992-1996, NASA's COST LESS team (including its predecessor teams) laid the groundwork for a radical redesign of the costly processes used by the Agency's Strategic Enterprises to build and buy space mission systems. The redesigned processes, when institutionalized, provide an exit path from engineering one-of-a-kind, complex systems and acquiring them through large consolidated contracts. Movement along this exit path may be tracked by the extent to which NASA lets go of what has become familiar and redirects its freed up assets to premier research and development.

The COST LESS team was initially commissioned to advise how NASA's space communications program could be conducted faster, better, and cheaper.

Having demonstrated ingenuity as a catalyst for change within a major program, the team's scope and membership were broadened to encompass the NASA family. The new team, composed of self-directed, volunteer representatives from government, industry and academia, was endorsed in 1994, by NASA Administrator Daniel S. Goldin as a cross-cutting, strategic agent for "faster, better, cheaper" change (see Reference 1).

With this endorsement, the COST LESS team set out to challenge established traditions. Two traditions were selected based on a previous finding that unnecessary uniqueness and complexity are linked with increased costs and schedules. The first tradition was custom-building and custom-buying space mission systems around original or unique requirements. The second tradition was accepting the resultant complexities as inevitable and accommodating them with extensive chain-of-command reviews and controls. The team undertook these challenges to realize "breakthrough" results of the kind offered by reengineering experts (Reference 2). The team viewed breakthrough as the action of breaking through an obstruction. The obstructions were "stovepipe" or insular management behaviors within organizational boundaries, discipline walls, funding partitions, functional decompositions, and life cycle phases. Experience had shown that rewarding these obstructionist behaviors disincentivized the discovery of fundamental similarities across the groups, and produced mission-peculiar, project-unique, and organization-specific systems when not merited. Further, this collective shortcoming in acknowledging similarities was a major source of unnecessary complexity that generated unnecessary duplications, e.g., building and buying custom systems to perform comparable functions, or reviewing and controlling the building and buying of these custom systems.

The COST LESS team entered into candid collaborations with decision-makers and joined in pre-competitive research with colleagues, who were dispersed across the diverse boundaries (e.g., organizational, discipline, functional, geographic, and political) the results were intended to transcend. Following an international workshop in May 1995, the story of FRED (discussed in section 2) began to unfold (see References 3 and 4). FRED presents a bold alternative to the status quo, and demonstrates technical and business ingenuity to create a robust and adaptable marketplace that anticipates, meets and exceeds customer needs (Reference 5). The marketplace paradigm offers NASA an opportunity to reduce dramatically the cost of success and to position itself, not merely to survive, but to thrive, in a continuing constrained fiscal environment.

2. The Underpinning of FRED

2.1 Confronting the Mystique of Uniqueness and Complexity

As an advanced technical idea, FRED (Fundamental Reusables for Enterprise Deployment) reflects the innovation of designing and constructing "faster, better, cheaper" space mission systems that appear unique, but in fact, are a synthesis or assembly of reusable components. A reusable component is the most basic unit or building block of system construction, and embodies fundamental functionality. It is a consequence of successfully reengineering business management and technical life cycle processes, removing their unnecessary uniqueness and complexity, and thereby discovering first principles (i.e., fundamental functionalities) that cut across NASA's Strategic Enterprises and other management boundaries. Conceived in this manner, building blocks are few in number and genuinely cross-cutting, regardless of enterprise specializations, such as human vs. robotic missions, or customary system groupings, such as space vs. ground segments, or planning vs. conducting space missions. Reusable building blocks may be readily assembled into reusable system solutions, which are capable of being used commonly and routinely to satisfy seemingly dissimilar needs, in seemingly dissimilar circumstances, and under seemingly dissimilar conditions (Reference 6). Examples already demonstrated proved that the same building blocks could be used for seemingly disparate activities, such as organizing processed telemetry data, controlling onboard experiments, searching science archives, reducing and presenting information to scientific users, and supporting educational outreach.

This synthesis (or assembly) approach is limited today only by the availability of bona fide building blocks (e.g., hardware, software, designs and architectures, data structures, algorithms, operations concepts and procedures). Reusable building blocks are in short supply, as a consequence of decades of shortsighted technology investments and parochial business incentives for designing and constructing unique system solutions within conventional management boundaries. A more overarching approach was considered at an international gathering of seasoned engineers, scientists and managers , themselves dedicated to "Hunting Sacred Cows"; a sacred cow is a belief or assumption that is so well established and revered that it seems unreasonably immune from ordinary criticism, even of the honest or justified kind. The workshop output yielded six insights with corresponding lessons to be learned (Reference 7). The insights confirmed once again that unnecessary uniqueness

and complexity lead to increased costs and schedules. The traditional system development and program/project management life cycle processes were singled out as preserving the status quo of building unique and complex systems around management-peculiar requirements.

2.2 *Creating a Marketplace Paradigm*

As a compelling business case, FRED (Find Redundancy, Eliminate Duplication) reflects a marketplace strategy that emphasizes assembling reusable components to deploy "faster, better, cheaper" space mission systems that anticipate and exceed customer needs. The keystone for FRED is to create an enduring reusability product pipeline or a supply chain of reusable components that have been fabricated from fundamental functionality decompositions, rather than from organizational functionality decompositions.

Assume that such a supply chain has evolved which offers products, product/service bundles, and standard pre-priced options for integration services, and where the integrators have in-depth knowledge of the available products. Further assume that a *mechanism* exists for space system demands, like those of NASA's Strategic Enterprises, to be communicated to the supply chain, and for the supply chain vendors to respond with solutions. (Consider computer system integrators who know how to select and assemble computer equipment components from competitive vendors to produce customized solutions in response to customer needs.) This mechanism is called the marketplace. The transactions of the marketplace are buy/sell events, followed by after-market support from the sellers (vendors) to the buyers. By employing this mechanism, NASA would begin to let go of the familiar (i.e., be a smart builder of one-of-a-kind, complex systems) and emerge as a smart buyer of products, and possibly as an architect of their assembly into space systems. Further, NASA would not perform research and development (R&D) at the component level, unless no supply chain existed, or no alternative synthesis of available components could achieve a comparable outcome. NASA would pay for a fraction of the vendors' product R&D through market-driven pricing of the vendors' products.

It is envisioned that FRED would make use of the Internet and other electronic means as a connecting link between buyers and sellers. As a trusted broker for the buyers, FRED would aggregate and publicize NASA's need, review vendor offerings, provide component assembly/architecture services as requested, and conduct ordering and delivery transactions. As a trusted broker for the sellers, FRED would publicize vendor offerings in "yellow pages"-type directories, support on-line search tools, conduct outreach for new products and

services, simplify buy/sell contracting, and coordinate with non-NASA buyers to expand vendors' sales potentials.

3. The Benefits of FRED

FRED provides for proactive matchmaking to benefit both the supplier and customer communities. Supplier benefit would be measured by the opening up of new markets, particularly for the non-traditional aerospace companies with genuine cross-cutting product lines. Customer benefit would be measured by NASA's incentive to become smart buyers and influence the marketplace to provide products and services that anticipate, meet and even exceed their needs.

3.1 Supply Side

Non-traditional aerospace companies and high-technology product developers have not responded regularly to NASA's business opportunity announcements to custom-build and/or operate space mission systems around organization-specific requirements. Typifying an entrepreneurial bias in lieu of government contractor status, these companies do not consider such opportunities as attractive as offering a product line that would be useful and applicable to a sizeable and varied class of potential customers which could include NASA (Reference 8). The prerequisite for developing a multiple-use, and hence cross-cutting, product line is, in fact, the underpinning of FRED, i.e., the identification of fundamental functionalities that transcend seemingly dissimilar customer environments. As a class, entrepreneurial product vendors are well-suited for abstracting requirements obtained from multiple sources, conceptualizing generalized components or modules as potential products, arranging the financing necessary for bringing the products to market, and organizing the after-sales support for these products. Thus FRED conforms to skills that are already prevalent and well-honed in the product supplier marketplace.

As NASA (as well as other public sector agencies) becomes proficient in expressing its demands as customer needs and expectations, the entrepreneurial suppliers will gain entry into previously restricted markets. This new "demand pull" adventure may appear to NASA as a new kind of "technology push", financed by the entrepreneurial private sector - technology to reduce unnecessary uniqueness and complexity, resulting in "faster, better, cheaper" commercial, reusable, and cross-cutting product lines (Reference 9). To the

entrepreneurial private sector, NASA will appear to have matured in its ability to discern similarities across its Strategic Enterprises.

3.2 Demand Side

Assuming that NASA can become an astute buyer and learn the mechanics of leveraging its own supply chain as other large buyers do, FRED represents a major risk management and mitigation strategy. By smartly expressing its needs, NASA will prompt vendors to initiate and conduct their own product R&D. Several responsive and responsible designs for components and subsystems will materialize without NASA having to make an early choice among sparse alternatives and to invest public funds in upgrading a poor choice. The risk will move from NASA to the marketplace, where incentives and rewards for making the right choices are present and the consequences suffered for the wrong ones are not paid for from public funds.

Under FRED, vendors will assume a greater share of (cross-cutting) product development costs and will amortize these costs over the largest practicable market. This should lessen NASA's reliance on (and sponsoring of) organization-peculiar, specialty-skilled labor procurements, and its resultant management and administrative complexities, to custom-build and/or operate space mission systems. Under FRED, NASA will see benefits from increasing the application of competitive forces. Competition for product sales among a larger set of interested suppliers will not only drive prices downward, but also apply upward pressures on reliability, ease of use or adaptation, after-sales support services, and performance guarantees. Properly exploited, NASA can use these market pressures to reduce economic risks and to assure that reliability is not sacrificed. Another benefit to NASA will be to shorten the time required to go from mission concept to mission readiness. Using the synthesis of reusable components that are commercially available, NASA can achieve the integration of a system in a shorter time than if component development remains in the implementation life cycle.

4. The Engineering and Entrepreneurial Alliance in FRED

During the dialogue between "Hunting Sacred Cows" workshop participants and the NASA Administrator, Mr. Goldin identified the need for the Agency to become a "smart buyer" and challenged the participants to develop a transition strategy. Embracing FRED is a pivotal step in evolving

NASA from a smart builder and sponsor of unique government systems to a smart buyer (i.e., customer) of cross-cutting private sector systems. While defenders of the status quo predictably view this upheaval as negative, innovators within NASA are prepared to pilot the technical and business aspects of building and buying assembled systems.

Trial opportunities for evaluating and buying assembled systems will help wean NASA from specialty-skill labor and service procurements toward component or product purchases. Moreover, these opportunities must be structured so that NASA matures its competencies in genuine process reengineering and team building, and acquires the engineering acumen to participate fully in the buyer/seller consensus essential to identify the underlying set of building block or product categories and their taxonomy. As the most basic unit of system construction, each building block will embody fundamental functionality, such that any changes over time are due only to technological advances that might alter the implementation details, but not the defining or distinguishing concepts. Properly performed, this reengineering exercise will generate the technical pillars for a powerful, responsive, affordable, and adaptable commercial space infrastructure.

Entrepreneurial prowess by the sellers and marketplace savvy by the buyers are required to create a commercial, reusable and cross-cutting supply chain. In order to assure an abundant supply of appropriate component options, NASA must learn to take full advantage of the market feedback to which vendors respond. Vendors hear an expressed need for a product and are willing to compete with each other to fill that need. NASA can shape its supply chain or reusable components if it: (1) capably expresses its future needs, (2) makes its needs (at least at the component level) conform as much as possible to those of other high technology organizations, thereby creating the largest potential market for the product vendors, (3) rejects products that are unsatisfactory, (4) participates in an open marketplace where match making between demand and supply is facilitated, and the buy/sell transaction is not unduly complicated, and (5) masters the skill of price, schedule and performance analysis vs. cost/schedule/performance estimating .

5. Motivating NASA to Embrace FRED as a Strategic Investment

5.1 Setting a Course for Bold New Directions

"...Thanks for being responsive and helping lead NASA in bold new directions." This was Administrator Goldin's reaction after reading an early

description of FRED. While these words were encouraging, they have been ineffectual in thwarting, or even neutralizing, the staunch defenders and preservers of the status quo. Mr. Goldin had previously noted that the COST LESS team represented good people who were challenging the current structure. They needed management support and assistance, including that at the second and third tiers. Mr. Goldin had also acknowledged that the change in culture would take time.

In hindsight, what is needed to reshape the culture is not management support and assistance, but rather strong, committed, persistent and passionate leadership for culture change at all levels. Charles Force, former NASA Associate Administrator for Space Communications, has advocated leadership over management when innovative change is the desired outcome. He characterizes leaders as seeking to expand options, not to narrow them; seeking to visualize new purposes, not to solve specific problems; and motivating others by inspiring and convincing , not through authority. He is also fond of giving comfort to change agents by quoting Machiavelli: "It must be remembered that there is nothing more difficult to plan, more doubtful of success, nor more dangerous to manage than the creation of a new system. For the initiator has the enmity of all who would profit from preservation of the old institutions and merely lukewarm defenders in those who would gain by the new ones" (Reference 10).

Just as "NASA is an investment in America's future" (Reference 11), FRED is an investment in NASA's future. FRED represents a breakthrough in both technology and government administration that, when institutionalized, will accelerate the return of NASA to a premier research and development organization. FRED, as a marketplace mechanism, supports the goals set forth in NASA's Strategic Plan and can be a self-sufficient contributor to the Agency's fiscal and mission effectiveness. Embracing FRED will send a clear signal that NASA is serious about doing business differently.

5.2 Contract Consolidation as a Tactical Pathway for FRED?

Agency managers are presently disposed to collecting current functionalities and responsibilities, and transferring them, in bulk, to the private sector as large consolidated contract and outsourcing packages. While NASA may gain some administrative efficiencies from having to deal with only a handful of contractors, consolidation may invite monopolistic practices and create barriers to entry for non-traditional, innovative business players. Additionally, the Agency may sacrifice the greater benefits and flexibilities

that an open, competitive marketplace would provide. Perhaps of greater significance is the Agency managers' striking disregard of the powerful economic advantages offered by a reengineered marketplace (Reference 12). Since the consolidation approach has no built-in incentives to reengineer across boundaries, savings may appear to be realized within each sector, but overall costs and schedules may actually increase.

FRED, as a marketplace paradigm, is based on end-to-end reengineered technical and business processes, as a way to Find Redundancy, Eliminate Duplication across NASA's boundaries. What if the Agency consolidation gurus were to incorporate a FRED-like mentality and structure incentives for smart buyers to find reusable solutions? They could implement the mechanics of the marketplace where the buyers (NASA's Strategic Enterprises) and sellers (vendors of reusable components) meet to synthesize solutions. Under the FRED approach, the consolidated contractors could become the outreach to vendors and the marketplace where vendors offer their solutions. Instead of the appearance, from a component vendor's viewpoint, of an impenetrable barrier to participation in NASA's business, the consolidated contractors could look like a welcome point of entry. Using the FRED approach, the management of the consolidated activities could focus on looking outward toward the many possible supply chains available to the Strategic Enterprises and get back on course for leading NASA in bold new directions.

Acknowledgments

The authors acknowledge the contributions from the "giraffes" of the global space community, those who dared to stick their necks out for revolutionary change.

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Report on Panel Discussion 1

Strategic Issues: National Perspectives (European and American)

The various issues of New Space Markets were discussed. All the speakers emphasized the private-public partnership. The expected benefits for the national economy will depend on how the specific partnership is shaped.

The Most Important Factor of Space Market Commercialization

According to P. Clerc:

In this changing phase CNES, the French Space Agency, needs to consult - and establish partnerships with - industry. Reduction in cost is the major factor in shaping new space markets. CNES should help industry to be competitive in the international arena.

According to K. Doetsch:

There is an evolution in the space market - technologies are changing. The main issue is what is affordable and what is not affordable; affordability is the main driving force of space markets. Sharing the cost, and doing good business, is the new market.

According to A.M. Hieronimus-Leuba:

The perspectives concerning space markets are bright. The most crucial thing is the right decision at the right time. Everything is changing and so is the space market. All have to face the situation without destroying each other. Common ventures save labor costs and other costs. Governments should help industry no matter how big or small, provided that the market potential is demonstrated and recognized.

According to R. Hornstein:

Two approaches are proposed: FRED as a technical idea - Fundamental Reusables for Enterprise Deployment - and FRED as compelling business case - Find Redundancy, Eliminate Duplication. Technical and business ingenuity

must be combined to create a robust and adaptable marketplace that anticipates, meets and exceeds customer needs.

In a nutshell, recognizing the public sector for some funding, finding a way for more funding through partnerships, and focusing on the demand side are the challenges to meet in creating new space markets.

According to P. Norris:

The trend is shifting towards the demand side rather than the supply side. Europe has been very successful in digital cellular systems. However, recognizing the public sector for funding and finding ways to secure more funding is the challenge.

According to K. Saul:

DARA is challenged to identify the prospects for space related applications which promise a sizeable economic and public return. The principle of reciprocity when accessing the expanding markets in Asia and the US, and the availability and importance of risk and venture capital for enabling innovative space-borne services of the future, are crucial issues.

Session 2

Strategic Issues: National Perspectives (Developing Countries)

Session Chair:

J. Adamson, Chief Operating Officer, United Space Alliance, USA

A Pragmatic Approach to Increase the Capacity of Developing Countries to Adapt and Develop Remote Sensing Technology

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Abstract

During the past two decades, data acquisition and supply have been the more dominant sectors of remote sensing technology. While many studies indicate that remotely sensed data provide cost effective and up to date information in managing Earth resources, use of the tremendous amount of already available data in meaningful applications has not reached its full potential.

The growing interest in the developing countries for more efficient natural resources and environmental management is creating new demands for techniques such as remote sensing to provide accurate and up to date information. However, while new applications of remote sensing are being investigated and introduced to the market in the developed countries, many developing countries are still struggling with their constrained capacities to absorb this technology. This paper examines the existing barriers to the use of remote sensing technology in the context of developing countries and suggests a pragmatic approach in encouraging its successful acceptance and adaptation. It discusses the major economic, institutional /social and geographical aspects that need to be addressed in the appropriate introduction and use of this technology. It also looks at various ways of facilitating the evolution of practical applications beyond the 'research tool' stage in satisfying the national needs of Earth resource management of developing countries.

1. Introduction

With increasing population pressures, the scarcity of natural resources and environmental pollution have become major concerns in the developing countries (DC). In their struggle for development, the availability of current and reliable information on their resources and the environment is becoming even more important. Often, such information is non existent, outdated, inadequate and/or unreliable. The conventional methods used are characterised by extensive labour and time requirements and high costs. The governments of these countries, therefore, will benefit from more efficient methods of data acquisition, storage and manipulation to extract vital information on their resources. The growing interest in the DC for more efficient natural resources and environmental management is thus creating new demands for techniques that provide accurate and up to date information. Currently, some of the most promising techniques available for Earth resources management (mapping, monitoring and planning) are provided by remote sensing from satellites. This is furthered by its capabilities for multidate, multispectral, multiscale and multidisciplinary analysis (Reference 1).

During the past two decades, however, data acquisition and supply have been the more dominant sectors of remote sensing technology. While studies indicate that remotely sensed data provide cost effective and up to date information in managing Earth resources, use of the tremendous amount of already available data in meaningful applications has not reached its full potential.

In the developed countries new space applications, especially of Earth remote sensing, are being introduced to the market accompanied by a growth in products and services oriented industries in the private sector. However, while new markets are expanding in the developed world, many DC are still struggling with their constrained capacities to absorb this technology. This paper examines the existing barriers to the use of satellite remote sensing technology in the DC, and suggests various means of encouraging the successful introduction and adaptation of it for Earth resource management of DC.

The present status of remote sensing for natural resources and environmental management varies greatly among DC. Some of them use it successfully at research as well as operational levels while others have very little capacity, if any, to absorb it. Other countries have moderate capacities, ranging from one or a few institutions with limited facilities to several institutions with trained staff and limited applications at research and operational levels. It is also important to stress that the need for this technology greatly varies among DC. It is assumed here that attempts to introduce or improve the current use of it will be based on a proper needs assessment.

2. Appropriateness of Technology or Appropriate Transfer of Technology?

Some argue that sophisticated information technology is too expensive to be afforded by DC and that information provided by modern technology is not what is essential to them (Reference 2). The cost factor is a reality that simply cannot be ignored. The need and relevance of the information is, however, a subject of controversy.

On one hand the DC have to manage their resources in a sustainable manner while struggling towards development and not pollute the environment, for which they need up to date and accurate information. On the other hand they are discouraged from investments in modern technology that provide such information. The labour intensive methods that are perceived as more appropriate to these countries fail to produce the kind of reliable information

which they can depend upon. This constrains their development efforts as well as the introduction of other types of technology. Mogavero and Shane (Reference 3) suggested the "scanty knowledge of local resources such as water, soils or raw materials as one of the more serious constraints to technology transfer in the DC" (p. 68).

While some experts strongly argue against the transfer of sophisticated technology to the developing world, others point out that many of the DC have the potential to adapt them. "In many DC, development is not constrained by lack of scientific knowledge but in the organisation of that knowledge into a useful form so that it can be adapted to local conditions and form a basis for technological development" (p. 69, Reference 3). Technology and its transfer has to be flexible in a manner that facilitates people in the DC to develop the capacity not only to receive, but also to innovate, new technology to suit their own conditions and needs (Reference 4).

The direct comparison of the appropriateness of satellite remote sensing to other technologies such as power plants, tractors or other agricultural equipment, however, is not appropriate. The process of and the criteria for the evaluation of appropriateness should not be equivalent or directly comparable to those of an industrial project. The process of technology transfer has to be tailored appropriately to suit the needs of the particular country. The process itself should contain mechanisms within it encouraging acceptance, adaptation and new innovations and should promote a smooth transferring process.

3. Factors that Constrain the Capacity of the DC in Successful Acceptance and Adaptation of Remote Sensing Technology

3.1 Economic Factors

For many developing nations the lack of financial resources is the major factor inhibiting the use of remote sensing. This discourages the governments and institutions in any investment in the technology as the requirements for its successful introduction and sustainable use cannot be met. Most DC, therefore, have to depend on external funding sources and the donor agencies often become crucial components in the transfer processes. However, in comparison with other development assistance projects, funding for remote sensing technology may take a low priority.

3.2 *Institutional Factors*

The lack of or limited availability of skilled staff, both at specialist and technical levels is a major institutional constraint in this regard. The absence or inadequacy of training programmes aggravates the situation as the other options would be to employ foreign experts or to send staff to be trained abroad. There also exists a need to raise the general awareness about the usefulness of this technology at the decision making and managerial levels of institutions pertaining to Earth resources management.

National remote sensing centres may face difficulties in performing their roles, especially if they embark on applications of the technology on their own. Their staff are often trained in remote sensing, yet may not have a background in Earth sciences. While they may possess the computer processing and statistical skills required to support their remote sensing know how, they may not have adequate thematic skills to be able to apply the technology in specific Earth resource management areas.

Working on applications without proper collaboration with the respective institution that manages a particular resource can also create obstacles to the processes of promoting widespread use of the technology. The latter institution which is more likely to have used the conventional data gathering, recording and manipulating methods may regard the information derived using the new technique suspiciously. This could be worse if quantitative information such as inventories resulted in discrepancies between the findings of the two institutions. This situation may discourage potential users. They may not be receptive to the new technology or the information derived using it.

Often the external support to establish national centres for remote sensing is directed to the surveying departments or an equivalent government organisation. This is mostly due to their already existing strengths in infrastructure enabling them to carry out operational level activities. These centres need to be empowered with adequate technical capabilities, authority and aspirations to support and influence the sustenance of the technology.

3.3 *Social Factors*

The process of technology transfer is primarily dependent on people rather than the institutions. The value of people with strong communication and interpersonal skills and open mindedness to innovative ideas has been mentioned to be a key factor (Reference 3). The current trends also strongly

emphasise the relationship of people to technology as a major factor in the successful introduction of new technology, especially computer technology.

'The socio-psychological effects of technology, the relationship of newer work systems and people, adjustment to new technology and management of change become important considerations in this regard (p. 166, Reference 5). In their analysis of computer systems within the psychosocial framework, Sharma and Sharan (Reference 5) discuss the challenges of computerisation for work psychology and quality of working life, stressing the importance of designing and managing computer technology with social responsibility.

Introduction of a computer based technology such as remote sensing will have implications on the work culture of an institution. Employees will be expected to work more independently; the institution will rely more on the skills of these individuals while the value and authority of some employees, who played key roles when conventional methods were used, may be affected.

3.4 Geographical Factors

Large countries with extensive areas of uninhabited and undeveloped land or those consisting of several or many small scattered islands create logistical problems especially during the ground truth collection phase of remote sensing projects if the transport, communications and other supporting infrastructure are absent. The frequency of cloud free images, as determined by the climate, also poses limitations to the use of certain types of analysis.

3.5 Political Factors

Access to the information on the country's resources by members of the public, especially the specialists, may be considered as a threat by the authorities. Governments, if they are inclined to use their power as the sole owners of such information, will not be keen to jeopardise their authority by investing in modern information systems (Reference 2) . Mogavero and Shane (Reference 3) described the "universal resistance to change, both rational and irrational" as one of the key obstacles to technology transfer in the DC.

4. New Markets

It is unrealistic to expect the availability of funds, except in a few rapidly DC, to change in the near future. Therefore, it is important for organisations dealing with products and services for remote sensing to have realistic

expectations of the demand and utilisation by these countries. The trends in the growth of demand, the needs for infrastructure and the types, quantities and frequencies of products to be supplied will be divergent and unique to each country. The users of this technology in the DC still remain predominantly in the domain of the public sector. The new markets expected to be created or expanded in the DC will thus have distinctive characteristics when compared to those of the developed world.

5. Encouraging Successful Adaptation and Facilitating New Applications

5.1 External Assistance

It is apparent that many DC would need some form of external assistance to promote the use of remote sensing. This support, depending on a country's needs and level of existing capacity, may range from the provision of products and services to a small country that may not need its own processing systems to the improvements to the infrastructure of one that has already established facilities. The more useful types of assistance include establishing national remote sensing centres, providing international expertise and training abroad (at the initial stages) and long term liaison with an institution in a developed country. Establishing smaller facilities regionally may be a possibility where the needs are not extensive or when national centres are not feasible.

5.2 Training

Once the initial training requirements are met local training programs have to be encouraged. National or regional remote sensing centres should have a strong focus on training. In training their staff, emphasis should be placed on obtaining skills to train others. Different types of training have to be designed catering to the diverse needs of people involved in the process. Collaborative training programmes should be encouraged with universities as that will provide an opportunity to combine the strengths of a national centre (in national or regional operational level activities) and those of a university (in training and specialist skills in Earth sciences). University staff in these countries who often obtain their postgraduate degrees abroad should be regarded as a ready made resource for this purpose.

5.3 National Planning and Networking

Coordinated national efforts. A goal oriented plan at the national level to coordinate all remote sensing efforts will help to minimise the

compartmentalised approaches often observed. This can avoid repetition of application and innovation efforts and duplication of funding. It will also improve communications between donors and assist in selecting and prioritising the projects suitable to receive support based on the national needs.

A national committee for remote sensing. The exact mechanism of executing a national plan may be country specific, yet a key element of it could be a national body (committee) on remote sensing based at the national or a regional centre. Members should be drawn from all relevant organisations including universities, Earth resource management institutions, donor agencies and policy makers. Streamlining all projects and providing the directions towards developing more appropriate techniques and practical applications to suit the local conditions and needs should be a main task of the national committee.

Networking. Establishing a national network of users will promote collaborative programmes that optimise the available resources. If a strong commitment is made a national inventory of resources could be created. This will be extremely useful especially in smaller countries or those still at the infancy of adapting the technology.

5.4 Educational and Research Activities

The universities should be encouraged to include remote sensing and its applications as a subject in the curricula of relevant courses. The undergraduate and postgraduate research work should be consistent with or be components of national or regional projects.

5.5 Changes to Work Culture

During the introductory phase, it is important to support the staff to adjust gradually to the changes that accompany the technology. Efforts have to be made to provide them the relevant auxiliary skills. Identifying staff that become redundant to facilitate alternative staff development options is essential.

5.6 Support to Countries with Low Capacities

For countries that do not have the capability to support their own systems, donor support can be utilised to provide products and services from a developed country. A liaison with an institution from a developed country or with a regional international organisation will extend the capacity of the recipient

country to adapt, and provide the contributing organisation with the benefits of consultancies and also with research and application opportunities.

6. Conclusion

DC are faced with many Earth resources management issues that can be addressed using remote sensing technology. The success of its transfer to DC depends largely on external donor support and the appropriateness of the transfer processes involved. While self reliance of the developing country has to be promoted, a long term liaison with an institution in the developed world will result in benefits to both countries.

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Integration of Remote Sensing Technology into Local Markets : A Policy Analysis

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Abstract

Limits to ecological harvests which societies face result from interactions between the society's physical resources and the ingenuity which the society can supply. Remote sensing as technical ingenuity is based on modern science which relies on often incomplete and inaccurate perceptions of reality. Traditional coping mechanisms as alternative ingenuity, usually embodied in culturally based value systems, are based on local level reality. The supply of remote sensing information is controlled by established market policies while traditional ingenuity relies on customer ideologies which are easily disrupted by the market forces. There is interference to the successful integration of remote sensing into the New Space Markets.

We analyse a policy framework which brings the technology systems together as it creates new space markets and effective partnerships. A working policy takes into account methodologies designed to obtain genuine information from the local people and to process it in the same way as remote sensing data is processed using GIS. It is envisaged that the end users become enthusiastic and interested in the new technical procedures and that this should result in improved communications and cooperation

1. From Science-driven Approach to New Space Markets

Our understanding of how remote sensing technology is important as a source of information for the management of human interactions with natural resources has increased drastically. A stage has now been reached where the technology should be brought into the market place so that it can generate some wealth for people as it sustains itself. Remote sensing has gradually been changing from a basically science-driven approach towards operationalization, and part of the transition is the creation of new space markets. This calls for a shift from academic research and development to commercialization which can be performed either by public institutions or private enterprises. Most private enterprises in traditional economies are found within local markets.

2. The Local Markets

Local markets are resource-based economies in transition from either pure pastoralism or agriculture to industrialization. Ideally, the transition should be accompanied by intelligently harnessed science and technology and a shift from poverty to wealth creation. The economic actors are agro-pastoral communities with small scale entrepreneurs who need a basic understanding of the worldwide supply and likely value of current and future resources. While

this need can be supplied by remote sensing information it provides a potential source for the remote sensing market. Access to remote sensing in such markets has, in the past, been through perceived application problems of space technology. The markets operate side by side with modern markets where development and successful marketing of remote sensing can be attributed to a balanced partnership of government policy, remote sensing industry and market research. The market aims at increasing the expected value of private gains and decreasing the expected value of private losses.

Modern markets tend to disrupt local economies whose marketing strategies are based on local value systems. The difficulty lies in the inherited marketing policies of science and technology which have, in the past, ignored local market initiatives. It is an economic requirement for the operational remote sensing information which is the key strategy to be driven by the underlying needs of those who require the information, their economy and prevailing environment conditions.

3. Income Sources

As the society strives to create wealth for its people and surmount resource scarcities, development, procurement and utilization of remote sensing technology becomes an important part of wealth creation. As we bring remote sensing into local markets a significant source of income is agro-pastoralism economy where the individual interactions with land, pasture and water produce wealth. Agro-pastoralists, traders and other economic actors need to have an understanding of worldwide supply and likely value of current and future resources. Anomalous conditions affecting the yields in real time can be assessed by high spatial resolution measurements and temporal analyses of remote sensing data. This might produce high accuracy in pre-harvest data for the farmer and early warning for pastoralists but the marginal improvements might not benefit the agro-pastoralist, even if the costs of using remote sensing data are collectively shared. Where the individual farmers fail to see benefits they lose interest in the technology.

Another possible source of revenue is the local traders who may gain economic viability by volume purchases of remote sensing data. In the context of the community the trader is the main beneficiary under economic terms of trade. Where market policy encourages the tender system, the lowest bidder is awarded the contract of procuring and selling the technology. The procedure lowers public expenditure but undermines local capacity to enter the market place, especially when the remote sensing product is new, the prices are high

and volumes are low. The local markets with small scale entrepreneurs are considered as obstacles to wealth creation and are neither given protection against undue competition nor given a specific apportionment of the tender awards.

The environment is a major consumer of remote sensing information for policy statements, etc., and, therefore, a potentially large market for the technology. The remote sensing market is expanded when a nation with variations in environments can be divided into several biodiversity regions. The people working in those regions can then form partnerships with local people to expand local markets. But remote sensing products are too expensive and prospective clients do not have large budgets. The public offices tend to view environmental issues as an enemy of the economy. Investments in human capacity in remote sensing to build a data base and define changes in biodiversity as a basis for policy making tends to be given less priority.

4. Demands for Remote Sensing Data

Effectiveness of bringing remote sensing technology into the market place is determined by the level of understanding and commitment of the individuals and organizations charged with the responsibility of interpreting and enforcing the market policy. Policies have not encouraged the development of indigenous creativity in most development situations.

Within the local market system the remote sensing market is dominated by policy makers with little exposure to private markets for space technology. The policy makers emphasize research and development and ignore an entrepreneurial framework for bringing remote sensing into the market place. Some of the potential customers are not aware of the existence of the technology and, where awareness exists, space technologists overemphasize the potential of remote sensing as the potential customers underestimate its value. And available resources do not generate enough income to meet the high cost of remote sensing products.

The development of local markets occurs only when the people have mastered the new skills and ability to transform knowledge into applied technology. This requires opportunities in technical education, research and development, marketing, technology transfer negotiations on the acquisition of technology and economic analysis. This requires a systematic and comprehensive policy to govern the transfer of technology and guide the development of local technological capacity.

The indigenous peoples are denied the scientific base necessary for innovations. The traditional techniques which are often highly localised are viewed as primitive and uninformed and, therefore, cannot compete favourably in the international market. Incentives to explore local potential are lessened as the explorers turn to modern technology.

Policy makers and space technologists and a community of enthusiastic users dominate remote sensing markets, but there is no effective network to bring remote sensing into the market place. Agro-pastoralists operate as private entrepreneurs. Conflicts occur between public and private sector markets where public policies do not encourage private ventures.

5. The National Will and New Space Markets

The objective is to propose a policy framework which brings remote sensing technology into local markets, as the local entrepreneurial capacity is built and business partners are formed within a society which is in transition from a resource based economy to industrialisation. The policy contributes to the amendments of the existing market policy to reflect national technological interests and the aspirations of the economic actors as remote sensing technology is brought into the market place.

The integration of certain elements of indigenous capabilities with remote sensing brings about the development of "high" science and technology upon which a country following an industrialisation path depends for economic growth. Innovations and marketing of remote sensing technology result in wealth creation by individuals. Partnerships among entrepreneurs improve communications and cooperation, and harmonizes various current and potential markets in order to sustain a remote sensing industry.

5.1 The National Will

The national will is expressed as a set of principles which should guide the supply of technical ingenuity. Kemya's national will is to: (1) make technological innovations based on domestic research and development findings and to commercialize the new technical procedures; (2) intelligently harness science and technology development for well defined courses for poverty alleviation and wealth creation; (3) society to make aware of the existence of the innovations. The people are required to generate the income necessary to stimulate commercial activities through an increased demand for consumer

goods and services. The guidelines enable us to collect local knowledge, merge it with remote sensing information and commercialize the findings.

5.2 *Market Requirements*

The successful entry of remote sensing technology into the local markets requires a policy orientation that views the new space markets from the point of view of customer ideologies that organize local markets as well as from the point of view of policies that guide the development of modern markets. For a nation basing its economy on natural resources, the potential for remote sensing market is related to the management and conservation of biodiversity. The sector expands the market when high spatial resolution measurements and temporal analyses of biodiversity changes are performed at sub-national level. Public spending on remote sensing could be directed towards the sector.

Demands for more remote sensing information is created when the policy encourages local markets and entrepreneurs to compete effectively and take responsibility for biodiversity utilization, conservation and protection. When the policy encourages private markets such as agriculture and livestock to flourish, the income generated increases the purchasing power within local markets. In the case of agropastoral markets, reforms occur when the individuals are made aware of the benefits of a careful combination of remote sensing, cattle sales and management of pasture and water.

5.3 *Innovations and Entrepreneurial Education*

A policy is derived with regard to the existing resources and the technical and social ingenuity by which the resources are developed. For integrating remote sensing information into local markets, a system of approving the appropriateness of the technology for local use is required. Attempts should also be made to ensure consistency with the national technological objectives. Appropriate technology is developed when methodologies are designed to obtain genuine information from the local people and process it in the same way as remote sensing data are processed using Geographical Information Systems (GIS).

Using GIS and a properly referenced coordinate system it is possible to obtain useful information about the real world. A field-based approach sees the real world as a non-empty space and this is where thematic data from indigenous sources can be recorded. The object-based approach sees the real world as an empty space filled with individual terrain objects. This is where

remote sensing data can be recorded. Both data sets can be synthesized and become a georeference for biodiversity conservation and management. In the case of an agro-pastoral economy, indigenous knowledge includes grazing patterns following changes in seasonal variations, crop cultivation following the availability of water, and knowledge of the geographical location of resources. Remote sensing information includes digital maps showing the distribution of pasture and water availability. In this way the economic actors working with remote sensing teams become enthusiastic and interested in the new technical procedures and organize local markets for remote sensing.

As the new technical procedure is made, knowledge of the innovations and marketing of the new technical procedures should be organized in such a way that they respond positively better to wealth creation by the individuals and to the appropriateness of technological capacity of the country and the sustainability of the industry. A feasible approach is to build entrepreneurship and education in remote sensing. This will enable the entrepreneur to understand the environment and the resources contained therein, and make resource management plans with customers using GIS, as he follows the policy guidelines and the needs of the customer. In the end he should be able to market himself and the remote sensing technology.

6. Entrepreneurial Partnerships

Each section of society has different needs; therefore, policy guidelines must harmonize the needs taking changing conditions into account. The new technical procedures should bring stakeholders together as they improve communication and cooperation in a remote sensing market. Stakeholders are the guardians of resources who organize local markets to generate income. In a pastoral community the guardians have several committees overseeing the overall management of agro-pastoral resources. The links between various committees in the neighborhoods are not consistent and this may, at times, result in conflict between farmers, pastoralists and wildlife for the use of pasture, especially during the dry season.

The committees also form partnerships with donor-funded organizations, the remote sensing industry and technical entrepreneurs, both local and foreign, in remote sensing who should provide remote sensing data at reasonable prices. They also create partnerships with the government which provides procurement and utilization guidelines.

7. Conclusion

Remote sensing technology has reached a level where it is of service not only to the people who largely depend on a resource economy for survival but also to humankind at large since we all still rely on the environment for present and future survival. It is important to make appropriate innovations in the technology and to commercialize the findings. There is potential for remote sensing markets and sustainance of the remote sensing industry. There is a need to establish the infrastructure for stimulating remote sensing markets at a local level.

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China and the International Space Market

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Abstract

China's own special history as one of the major space countries is reflected in the development of its space technology, the application of which holds great potential. In view of the importance of technology transfer to the development of new space markets, and of the fresh opportunities which a socialist market economy offers for the transfer of space technology in China, the authors analyze ways in which the Chinese space sector should market this technology, simultaneously introducing state-of-the-art technology and concepts from other countries into China. In this way, new areas of cooperation with counterparts worldwide may be created within the Chinese space sector, in addition to the commercial satellite launch market.

The development of space technology for transfer to new markets in China presupposes a highly professional approach to technology development and to decision-making processes in business. Professionals involved in such development should have a unique sense of innovation, the ability to assimilate new information, outstanding development skills and a striving sense of international cooperation. The training of space professionals for such cooperation in the international arena may be achieved through various channels, such as active participation in international space activities, effective networking for liaison and information exchange, training courses in space technology using advanced media, etc..

1. China's Achievements

China's space industry has followed forty one years of an arduous but glorious career. Under the condition of backward science and technology, lacking in industrial and economic foundation and unavailable international cooperation in those days, China constructed and developed its own space industry system with surprising speed. China's space industry has made world-famous achievements from initial imitation to independent design, from single product development to the production of various spacecraft and space technology transferred to the civilian production, which has set up an example of developing space technology independently; some of its technologies have ranked with the most advanced in the world.

1.1 Growth and Progress of China's Space Efforts

In 1956, the newly founded China brought rocket technology into the twelve-year program for national independence and development while facing

severe economic and political difficulties. In 1965 to launch a satellite became a national key project. On 24 April 1970 the first artificial satellite made in China was launched successfully from the Jiuquan Satellite Launch Center and China, following the Soviet Union, the United States, France and Japan, became the fifth country in the world to launch self-designed satellites with self-designed launch vehicles. In 1975 China became the third country in the world which mastered the satellite retrieving technology after the United States and the Soviet Union. In 1984 the successful launch of an experimental communications satellite showed that China became the fifth country in the world to launch a satellite into the geostationary transfer orbit. In 1990 the first pilot launch of the strapped-on launch vehicle Long March 2E was successful.

China's territory investigation satellite, photographic positioning satellite, communications and broadcasting satellite and meteorological satellite have been developed rapidly and put into application. Since the Chinese government announced the Long March Launch Vehicle Series on the international market in 1985, China has successfully launched the communications satellite Asiasat 1, a Pakistani satellite, a Swedish satellite and an Australian satellite.

1.2 Space Technology with Chinese Characteristics

Because of the closed developing environment over a long period, all the Chinese satellites and launch vehicles were designed and developed by China itself. At that time space technology was the newest discipline, so the Chinese engineers and technicians learned and practiced in a new field with a scientific and diligent attitude. Not only did they solve problems, whether China had the space products or not, but also commenced independently to develop the second generation products and even more advanced space technology.

China has an advantage while developing the space technology, i.e. it brings the pilot satellite directly into application, which has resulted in good benefits and reflected the Chinese characteristics of developing the space technology with low cost and high effect. Compared with the European Ariane rocket of a similar capability, which costs $ 0.8 billion and took seven years of development, the cost for China to develop such a rocket is one-third of Ariane's and the time was only three and a half years.

2. Developing International Cooperation and Advancing into Space Markets

Since China implemented the policy of reform and opening to the outside world, and the socialist market economy, three satellite launch centers (Jiuquan, Xichang and Taiyuan) have been opened successively to provide a commercial satellite launching service for foreign clients.

In October 1985, after the eighth successive successful retrieval of a sensing satellite, the Chinese government announced that the Long March rocket series would be put on the international market to provide launch services for foreign countries. Two years later, i.e. during August and September 1987, China launched two retrievable satellites, one of which offered a piggyback service for a French company and performed a microgravity test successfully. This was the first time that China provided a launch service for a foreign customer. In August 1988 when once more launching a retrievable satellite, China successfully carried out a microgravity test for a company in West Germany; foreign professionals were allowed to join the launch activity in China for the first time. From then on, China started a new space cooperation with foreign countries and took the first step into the international space market.

In spite of the short time to carry out international cooperation in the space field, China has made a great influence on the world. For strengthening the competitivity in the space market, China needs to foster qualified space professionals who can not only market the advanced Chinese space products and services to foreign countries but introduce state-of-the-art technologies and conceptions from other countries so as to accelerate the development of domestic space technology. More and more people with breadth of vision have recognized that the training of space professionals is of vital importance to China's destiny and future in the international space market.

3. Training Space Professionals

With the rapid development of space technology in the world, the international role of China's space technology is faced with a severe challenge. To reach the national foreseeable developing objectives and long-term strategic goals, it is necessary for China to maintain the development of space technology, especially in technical innovation and technology transfer. It needs to foster a strong team engaged in technical development and the commercial decision making process. These professionals must be secure in the space technology and have a unique sense of innovation, the ability to assimilate new

information, outstanding development skills and a striving sense of international cooperation simultaneously.

Because of its high complexity, space technology involves several disciplines and high technologies. China High-Technology Industry Association for Continuing Engineering Education (CHTIACEE) was founded in 1986 to train diversified professionals meeting the requirements of various industrial structures and to lay a solid foundation of human resources for reaching the strategic goal of a sustainable Chinese space industry according to the intensive technologies and various disciplines in the space field.

3.1 Features of CHTIACEE

CHTIACEE consists of ten national departments closely concerned with the space industry and seventy-eight units subordinated to them, which form a comprehensive network throughout the country and take the integration of scientific research, production and education. The ten departments are the Commission of Science, Technology and Industry for National Defence, the General Corporation of Space Industry, the General Corporation of Aviation Industry, the National Civilian Aviation Administration, the North Industry (Group) Corporation, the Ministry of Nuclear Industry, the Ministry of Mechanical Industry, the General Corporation of Ship-building, the Engineering Physics Institution and the Ministry of Electronic Industry. Belonging to the association there are several million employees and, among them, are nearly one million engineers and technicians.

Since its foundation, CHTIACEE has always stuck to the continuing engineering education, promoting scientific research and development and focussing on the technical cooperation and exchange, at home and abroad, which has become the important base for China's space sector to cooperate with other high-technology fields as well as training high-level qualified professionals.

3.2 Promoting Cooperation of Domestic High-Technology Industries

From the very beginning, CHTIACEE has maintained the tradition of China's high-technology industries paying attention to training employees on the job and according to requirements. It organizes an annual conference of high-technology continuing engineering education on the challenges facing the high-technology industries, exchanging experiences, exploring how to carry out professional training, space technology development, civilian product

development and improving quality, etc.. The presentations at each conference are compiled into a proceedings series named "Exploration and Practice". Furthermore, as the national collaborative organization of high-technology industries, CHTIACEE disseminates timely scientific and technical outcomes and achievements of the scientific research sectors, production units and universities, by publishing and circulating its bimonthly "Continuing Education", "Continuing Engineering Education Newsletter", paper proceedings, different symposiums, seminars and courses so as to realize the combination of production, learning and research in the space high-technology field.

3.3 Taking Active Part in International Cooperation

According to the close relationship between the development of space technology and international cooperation, CHTIACEE has taken part in international space activities, particularly in space professional training. First of all CHTIACEE is one of the founders of the International Association for Continuing Engineering Education (IACEE). At each World Conference of Continuing Engineering Education (WCCEE) held by IACEE every three years, papers from CHTIACEE are presented.

The other outstanding international activity of CHTIACEE is actively to participate in the training of space professionals by the International Space University (ISU). CHTIACEE has supported the ISU for its training activities from the very beginning for CHTIACEE recognizes the unique role of the ISU in peaceful human developments in outer space, especially its innovative education style - international, interdisciplinary and intercultural - which meets the requirement of training qualified and competitive space professionals. So far CHTIACEE has appointed some twenty participants to the Summer Session Program (SSP).

With the 47th International Astronautical Federation Congress held in Beijing in October 1996, China took a further part in international space activities. Taking the new opportunity CHTIACEE established an effective information exchange and liaison channels through joining the international space network, professional seminars, academic symposiums, scientific and technical exhibitions, etc., held different space training courses in collaboration with other organizations so as to discuss the current situations and the future of human's using space peaceably, and established a good environment for performing the international high-technology cooperation and professional training.

4. Significance and Prospect of Space Technology Transfer

As one of the high technologies, space technology is a comprehensive engineering technology for exploring, developing and utilizing space and other celestial bodies beyond the Earth. For the developing countries, it is a development opportunity as well as a challenge to carry out research and development (R&D) for various spacecrafts and applicable space technologies for peaceful purposes.

4.1 Space Technology Introduced Abroad

China has ranked among the advanced in the world for its technologies of retrievable sensing satellites, multiple spacecraft onboard a single rocket, telemetry, and so on. Because of the low research cost and high reliability, the above-mentioned Chinese technologies have big advantages to market and transfer to the international market. Moreover, as one of the items of continuing engineering education, technology transfer can be carried out through training.

4.2 Introducing Advanced Technologies from Foreign Countries

Generally speaking, China's space technology falls behind that in the developed countries and there are still many gaps to fill, for instance it is necessary to improve the transmitting capacity of the practical communications satellites, the stability of the large launch vehicles, the payload of the retrievable satellites, and so on. To carry out technical innovation, attention must be paid to the introduction of the world-wide advanced technologies to strengthen the domestic scientific research ability in addition to the dependence on the R&D sectors to carry out the transfer of products and technologies, i.e. to transfer the technical outcomes into production rapidly.

4.3 Introducing State-of-the-Art Professional Training Factors

In the 1990's China worked out a project named "Torch" aimed at promoting the commercialization of high-technology outcomes, the industrialization of high-technology commodities and the development of high-technology industries. Such objectives pose newer and more requirements for training high-technology professionals including the space professionals; the goal of high-technology education should focus on training three kinds of creative abilities as follows:

- Ability of innovating and inventing technology, i.e. the fundamental ability.
- Creativity of applying technology, i.e. the ability to transfer technology into the products and services resulting in social and economic benefits.
- Creativity of marketing the products and services only through which can the final economic strength and commercial competitivity be formed.

Nowadays the replacement cycle of technical knowledge is shorter and shorter. To master the state-of-the-art knowledge, theories, technologies and market trends, the Chinese space professionals must be provided with practical, intensive courses to maintain the sustainable, stable and effective development of products. Thus it is an easy and quick way to train the space professionals through introducing teaching strengths and materials from the advanced countries or studying in foreign countries. At the same time as they teach, the foreign experts can demonstrate the applied up-to-date space and teaching technologies, such as Internet, multimedia, CD-ROM, telematics, etc., so that the participants can grasp these advanced applicable technologies for teaching, learning and using.

Obviously there is great potential for China to carry out international cooperation, technology transfer and introduction of space technology, as well as the space industry development and professional training.

5. Conclusion

China's space technology development should be based on its own situation, give priority to seek the advanced space technology, persist in its own developing way, strengthen the international cooperation, introduce up-to-date technologies and foster a qualified space workteam in practice. Space technology can be applied in the economic sector for solving the problems that China is facing, such as education and culture, communications and traffic, environment and disaster, population and resources, etc.. As human society approaches the new century, the world is experiencing a tremendous revolution. With the rapid development of space technology and fierce market competition, international cooperation increasingly tends to developing space resources because of the global feature of space activity and its intimate relationship with the human community. In addition, because of the high cost, long duration and high risk of space technology and product development, international cooperation, especially including technology transfer, is a shortcut to save funds, accelerate the process and train high-level space professionals at the same time.

Report on Panel Discussion 2

Strategic Issues: National Perspectives

(Developing Countries)

J. Adamson underlined that, in the past, industry was driven by the supply side, with the governments playing the role of both the supplier and the customer. Therefore, little attention was paid to the market. The governmental approach has changed; what the market is now has to be defined. Launchers have to be considered as implementing tools, necessary for fulfilling the market needs. In the future, there will be the need for new emerging capabilities and the need for an infrastructure based on the development of launchers and human operations.

Panel Discussion:

J. Adamson

A. Jayesekara

N. Ochanda

The panel discussion focused on the impact of the Remote Sensing Center of Technology Transfer of Nairobi on the local market. The importance of education before training, and the creation of a partnership to allow the developing country to benefit fully from technology transfer, was stressed. Moreover, the essential role of the political leadership in supporting the technology transfer process was underlined.

Panel Discussion:

J. Adamson

K. Andoh

The discussion focused on the importance, for small companies, of being creative, in order to stay in the market.

Panel Discussion:

J. Adamson

G. Khozin

N. Tolyarenko

Big social changes in Russia are forcing the Russian Space Program to change as well. This is a transition period for Russia. The Russian Space Program is currently underfinanced, undersupervised and undersupported, due to a lack of willingness at the level of decision makers and a lack of communication between decision makers and technical experts.

Keynote Address

New Markets: The Role of Exploration

M. Mott, Associate Deputy Administrator (Technical), Office of the Administrator, NASA Headquarters, Mail Code AT, Washington, DC 20546-0001, USA

1. Spin-offs from Space Programs

"Space affects all of us and all that we do, in our private lives, in our business, in our education, and in government. ....We shall succeed or fail depending on our ...success at incorporating the exploration and utilization of space into all aspects of our society and the enrichment of all phases of our life on Earth." That statement was made on May 6, 1958 by Senator Lyndon Johnson, then Chair of the Special Committee to create NASA.

I would like to begin by telling you where I think new markets fit in to what NASA's doing. I am only going to address the space side of NASA's activities, not our aeronautics program. Let me just give you a few examples of how space-driven technology has created new markets and made life better here on Earth.

- We developed tiny sensors that measure the pH of body fluids for use in space research. They are being modified by pediatric surgeons and biomedical engineers to monitor the post-operative health of unborn patients who were operated on to correct congenital defects.
- We grow protein crystals in space to get a better understanding of a new generation of designer drugs that could potentially treat a variety of diseases from AIDS to diabetes.
- The Hubble Space Telescope, in addition to providing revolutionary scientific discoveries, has also led to breakthroughs in mammogram screening and digital imaging.
- An ultraviolet spectrometer was developed that analyzes water and wastewater on-line and in real time, detecting iron, chlorine and heavy metals. It is making life safer for people and it has been an economic boon for the company. Over 50 systems have been sold for about $2 million.
- NASA helped a Mississippi inventor produce a condensation overflow sensor for air conditioning units and heat pumps. It stops condensation from building up and spilling onto ceilings or floors and causing huge damages.

It is scheduled for market this year. In the South alone, it is estimated this device could save home owners $500M in damages from 1997-2002.

- NASA collaborated with industry and university partners to develop and transfer the use of remote sensing and associated computerized technologies to assist wine growers fight a root disease named phylloxera. The retail value of the wine industry in California is over $14 bill./year.
- An ocular screening device is helping to detect vision abnormalities and diseases, some of which can lead to blindness if left untreated in children as young as six months of age.
- A new technology was developed to examine astronauts' retinas in space - that led to a digital retinal fundus camera, a funduscope, which can be used via telemedicine, linking specialists with patients and colleagues in rural areas.
- NASA developed a lightning detection and location network, providing real time information to users by telephone lines. A company commercialized the lightning detection system. New software was developed to combine the data received from NASA with information from Doppler radar. These modifications resulted in a storm warning system that will plot a dangerous storm's projected path, instantly identify all communities affected by the storm, and estimate when the storm will arrive at each community. Rescue and utility crews now have advanced warning about potentially dangerous storms, enabling them to provide a faster response to areas affected by the storm.
- High pressure pump and computational fluid dynamics technologies used for the Space Shuttle Main Engine have been applied to the design of a revolutionary heart assist pump. This is unique because of its compact design, the fact that it has only a single moving part, and the fact that it is a seal-less design. It will work for almost anyone in need of a heart assist pump, but its design is particularly ideal for smaller-bodied patients, particularly women and children, whose chest cavities are too small for the large, complex designs that preceded this model. Given its simplicity and its elegance of design, it will work longer and better than its predecessors, extending the possibility of its use to many more people. Currently some 60,000 patients a year are in need of a heart transplant, but only some 2,200 hearts are available. This device will fill a need for many patients, not just extending their lives, but also greatly improving the quality of their lives.

These are all great spin-offs. They make life better for people, they boost industry, and create new opportunities. However, when we talk about creating large-scale, lucrative, cutting-edge new markets in the future, in space or on

Earth, I believe that these will come only as the result of bold exploration of space. I believe that Space Exploration is the ultimate investment in our future.

Why do we explore space? Why did we go to the Moon? Why do people all over the world look up and wonder when human beings will again walk on another planetary body? It isn't to create new markets. It isn't to create new jobs or industries. It isn't about economics at all. We are by nature explorers. For centuries, we have left the warmth and safety of what was known and stepped out into the unknown. We reach, we seek. We boldly go.

I submit that we in government do not know what makes sense commercially. We do not have the expertise to determine what makes sense financially. The high technical requirements for success in space exploration are so fundamental that commercial applications and rewards are almost automatic.

2. Moon Missions

Let us take a look at Apollo. Clearly, we didn't go for the spin-offs, we didn't go for the commercial applications, we didn't go for the scientific return, although that proved significant, we didn't go to create new markets or to create new jobs or industries, or for economics at all. We might have even gone for the wrong reasons, beating the Russians and winning the Cold War; however, look at the outcomes.

We are all aware of the contributions to computer technology, error free software, integrated circuits, bearings for rotating machinery, light weight batteries for cordless tools, composite materials and structures, the first digital display terminals for Mission Control, biomedical monitoring of astronauts enabling emergency medical treatment by paramedics and emergency rooms, fire suppression, detection and protection equipment, quartz crystal clocks, dry lubricants, fuel flow measuring and monitoring systems, emergency lighting systems, and xenon arc lamps. Here are a few that are not so well known.

- The Apollo space suit has led to "cool" suits used by firefighters, crop dusters, those who work with hazardous materials, MS patients and children with a disease (hypohidrotic ectodermal dysplasia) that causes them to overheat quickly.
- Apollo technology has been incorporated into a system called the Advanced Computed Tomography Inspection System (ACTIS). The medical version of CT scans the human body for tumors or other

abnormalities. The ACTIS system finds imperfections in aerospace structures and components, such as castings, assemblies, rocket motors and nozzles, and is the most versatile CT scanner available for non-destructive testing.

- Black and Decker used technology from the Apollo program in new cordless lightweight battery powered precision instruments that give surgeons optimum freedom and versatility in the operating room.
- Technology developed to monitor astronauts' respiratory gases in spacecraft is now being used in operating rooms for the analysis of anesthetic gases and measurement of oxygen, carbon dioxide and nitrogen concentrations. It assures that patients undergoing surgery have the proper breathing environment.
- Glare from computer screens has been blamed for blurred vision, eyestrain and headaches. A coating now being used on screens and for computer screen filters to cut glare was used to coat the windows of the Gemini and Apollo spacecraft.
- A metalized film developed for thermal radiation insulation during the Apollo program is now being used in the Thermos Emergency Blanket, which reflects and retains up to 80 percent of the user's body heat, helping to prevent post accident shock or keeping a person warm for hours under emergency cold weather conditions.

Large airplanes produce powerful wake vortices which can be hazardous to planes following closely behind. For this reason a five mile spacing is required between large and small aircraft approaching a runway to allow time for vortices to dissipate. With an eye towards reducing spacing requirements while assuring light plane safety, the Laser Doppler Velocimeter (LDV), developed from Apollo technology, enables airport controllers to determine when it is safe to land. The LDV is also used to measure winds aloft with greater accuracy than weather balloons and to measure smoke stack pollution dispersion patterns.

All of these applications of technology developed entirely for other reasons were used by commercial companies and entrepreneurs to create new markets and entire new industries. The government's role was to make the technology available to anyone that wanted it and let them determine the applicability of making it work commercially.

Consider what might result from doing something really daring, like sending humans back to the Moon and on to Mars. I still maintain that we in government do not know what makes sense commercially, or have the expertise

to determine what makes sense financially. However, let's look at some obvious developments that would result from such a bold journey.

We would need to develop systems that could keep the air and water in the crew transport vehicle clean and life-supporting. These systems would have a tremendous effect on Earth. Knowing how to filter out impurities in water and air would give us a much cleaner, safer environment. We would also need innovative new medical systems and treatments, medical techniques and procedures that could heal sick astronauts without scalpels or incisions. Could this result in putting micro-machines into their bodies that doctors could manipulate from the ground? The machines would need to be able to monitor what's happening in the body, and carry antibodies directly to a certain part of the body. Or go directly to where a medical problem has begun and resolve it.

That would open up huge markets in health care on Earth. The same kind of vital sensors which we put into the bodies of astronauts to monitor, diagnose and treat them from the ground could be used throughout the world to monitor a person's health and vital functions from a prenatal period to old age. They could be used by surgeons to make prenatal corrections, or to monitor continuously the elderly. If something went wrong, a doctor could be on the phone or another interactive system with a patient within minutes. People in rural areas and remote villages around the world could have access to high-quality health care. We could be diagnosed and treated in our homes; a hospital stay would become the exception, rather than the rule.

We would need a new transportation system from orbit to orbit. If it were to make a long trip, for months or years, it would need to be self-healing, like the human body. We would have to develop spacecraft that could detect and fix problems with built-in systems. Imagine the markets in aircraft, robotics, computers and biotechnology. Low cost access to space would open up the heavens to space exploration and commercial utilization. It would make possible a constellation of outposts in space, built and operated by a partnership of industry and academia.

We would also have to know how to live off the land if we sent humans to another body far from Earth. Successful expeditions on Earth lived off the land, instead of trying to take all their supplies with them. The same thing is true in space. The efficient production of fuel and water utilizing in-situ resources is necessary for energy production and for life. Today, in the 1990's, it takes two acres to provide the proper nutrition for one person. It would be too costly and too difficult to carry the supplies needed to do that to another planetary body.

We would have to figure out how to do it in tens of square meters instead. These crops would need to be much more productive, and have more nutritional value.

Exploring the Moon - especially with an eye to developing it as a way-station for longer-range exploration - would advance Earth sciences, and develop new, innovative technologies. We could tap lunar and solar energy resources. The investment needed to return to the Moon will truly be an investment in the future. Mike Collins, the Apollo 11 astronaut, said, *"The Moon is not a destination, it's a direction."*

Who knows what all the benefits and markets will be? Energy from space, advances in solar power and fusion fuels, useful materials for advanced communications, new resources, medical breakthroughs, and greater insight into the human potential are some of the direct benefits we can expect.

New technologies and scientific breakthroughs create new industries and new jobs. And they boost global markets, pulling in profits and stimulating the technological employment base. Furthermore, we are going to need the resources of space in the next century. We will need the technologies driven by space exploration. Information systems, biotechnology, biomedicine, artificial intelligence, remote sensing - these are the tools that our children will need to go to the cutting edge. Let's let the government make the bold steps and let the entrepreneurs use the results to develop what makes sense commercially.

3. International Collaboration

There has not been a better time to go to another planetary body in recent history. We have an incredible opportunity to cut expenses dramatically and expand expertise by working together. The United States cannot afford to do bold, large-scale exploration of space alone. Neither can anybody else. But in this astonishing new age, we have a rare chance to do together what we haven't been able to do apart. If we seize this moment, if we work together, we will leave Earth orbit.

President Kennedy considered a very bold international partnership during a far more challenging time - at the height of the Cold War. It is a little known fact, but, in September, 1963, President Kennedy went before the United Nations and suggested the possibility of a U.S. - U.S.S.R. joint expedition to the Moon. He argued that space offers no problems of sovereignty. He said there was no need to compete in space and urged against duplication of research, infrastructure and costs; he called for world scientists and astronauts to work

together in the conquest of space. We need to take President Kennedy's words to heart and start work on a bold new course of international cooperation. We need to decide what the "big things" for this generation are. International cooperation is critical to the future. If every nation just replicates what other nations have already done, we will just be chasing our tails. We will never leave Earth orbit if each country believes that it has to master all the technology, do all the research and pay for each piece of hardware. We have got to cut out expensive, unnecessary duplication that saps our budgets and quells any hope of capturing the world's imagination.

For example, when we begin a series of robotic missions to Mars, there is no reason why every country has to put an orbiting communications satellite around Mars. A country with a national need to develop that technology could take it on, while another nation tackles landing rovers on Mars and another works on the launch. What is important here is that we share the burden while doing what we need to do to meet our own national technological and competitive needs. We are all grappling with tight federal budgets, the pressures of global competition and the urgent needs of our people to be clothed, housed and fed. It makes much more sense for us to work together than to toil alone.

Does the world really need almost as many different launch vehicles as there are satellites to launch each year? Right now, there are 13 different families of boosters available from five different countries and Europe to put an estimated 140 communications satellites into geostationary orbit over the next 10 years. Yes, the market for sending small payloads to Low Earth Orbit is booming. But will it grow enough to support the four launchers now available as well as those being developed in Europe, Russia, the Ukraine, India, China, Japan, Brazil and the United States?

Cooperation, not competition, is the key to the future. Cutting out international duplication is not the only way we need to approach cost cutting. We need to work together to do this. Our plans for science and exploration need to be driven by the country's needs, not your needs, or her needs or his needs.

President Truman had a sign on his desk that said *"It is amazing what you can accomplish when you don't care who gets the credit."* That is the attitude we need for a real Space Exploration program to move forward. We must be unified so we can get the message out about why space exploration is critical to everybody's future.

4. Let's Boldly Go

Let's do some real Space Exploration. Between now and the year 2010, we as a world ought to launch robotic probes that will touch every part of our solar system. We can map out our solar system remotely, send fly-bys and land rovers to retrieve samples. Yet we must never forget that the best space exploration tool we have is a set of eyes looking through a visor.

We can do all this and more. We can go back to the Moon and on to Mars. Astronaut John Young said, *"I think you have to go back to the Moon and on to Mars because we need to get smarter faster and apply what we learned to help us solve the problems of tomorrow. We're not making enough progress in advancing science and technology for our grandbabies."* He is right. Let's give our grandchildren some new stories and pictures - a blue and green planet, circling another Sun, that may support life - microscopic fossils of life found on another planet - a crew at their base camp on the Moon - the first human footprints in the red dust of Mars. Let's do it. Let's do something bold and difficult and audacious. Let's create the new opportunities that will drive the new markets. Let's do it for the practical benefits. Let's do it for the impractical benefits, for the hope, the possibilities and our children. In 1961, we decided to go to the Moon. I think that it's time we decided to go back.

Session 3

Strategic Issues: Global Perspectives

Session Chair:

R. Doré, President of ISU

International Space Cooperation Applied to New Space Markets[1]

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1. Introduction

In the late 1980's the world entered a new phase as a radical restructuring of the international political landscape got underway. This fact, coupled with an explosion of technological capabilities around the planet and a growing realisation of the benefits that space technology could provide, created an environment conducive to enhanced international space cooperation. Recognising this situation, the International Activities Committee (IAC) of the AIAA, in 1991, initiated the organisation of a series of workshops on International Space Cooperation. To date three workshops have been held and the fourth is well along in its planning.

This paper reviews the results of the AIAA's Third Workshop (May 1996) as they relate to New Space Markets. In this workshop, that took as its overall theme "From Recommendations to Action", individual working groups were mandated to focus on specific international cooperative objectives and determine the political, managerial and financial processes by which they could best be accomplished. These mandates were to:

- Develop a strategy for assessing the utility of international cooperation to the implementation of specific initiatives, both governmental and non-governmental
- Develop a plan for the use of international space assets for disaster mitigation

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[1] Based on the report of The American Institute of Aeronautics and Astronautics (AIAA) Third Workshop on International Space Cooperation held in Frascati, Italy in May 1996 and co-sponsored by the Confederation of European Aerospace Societies. An overview of the Workshop series, to date, can be found in References 1 to 3.

[2] The authors are Co-Chairs of the AIAA International Activities Committee International Space Co-operation Workshops Subcommittee that is responsible for the promotion of workshop results and planning future workshops.

- Determine the role that international space cooperation could play in significantly reducing the cost of access to space
- Develop a strategy for non-Partner utilization of the International Space Station.

The output of Working Group deliberations is reviewed below emphasising, where appropriate, the identification and development of new space markets.

2. Working Group #1: Criteria for International Space Cooperation

The output of Working Group 1, while not directly related to "New Space Markets" offers some interesting insights into the applicability of international cooperation to their development. The wide scope and benefits of space activity make it an ideal forum for international cooperation; in fact this has been a common practice throughout the "space age". Bilateral and multilateral initiatives have, at one time or another, been established in most space disciplines.

Over the past few years, many factors have driven governments and industries to give consideration to more cooperative opportunities. The end of the Cold War has changed military and national security needs and altered national boundaries and societal groupings, creating a new geopolitical environment. The world's economy has become more global, and multinational companies now dominate the market and influence business operations worldwide. Governments of the traditional spacefaring nations are experiencing pressure on their discretionary budgets, causing a decrease in government-sponsored space activities and influencing programs, jobs, and markets. Although government expenditures are being reduced, the market for many space services is growing, and commercial enterprises are increasingly positioning themselves to satisfy consumer needs. There is also an information explosion occurring around us and we are seeing an increasing disparity in the global quality of life and are more than ever sharing environmental concerns about our planet. Finally, military technologies such as global navigation and Earth observation systems have become prevalent on the civil market, while the military is looking more and more to the commercial sector to meet many of its requirements.

Whether or not international cooperation is appropriate to the implementation of a specific initiative depends on many of these same factors. The Working Group, therefore, undertook to generate criteria for evaluating

new opportunities for international cooperation, be they government/government, government/industry or industry/industry. The target audience for application of these criteria was seen as:

- Government national policy groups
- Government budget authorities
- Government space agencies
- Foreign Ministries/State Departments
- Major investors
- Companies
- Private foundations
- Program managers in both the public and private sectors.

The criteria developed fall into two groups, as follows:

Group 1: Domestic interests	i.e. Does the proposed cooperation..
Foreign policy	Meet each nation's foreign policy, including such matters as laws, regulations, guidelines, and goals pertaining to the conduct of its foreign relations and cooperative activities?
National constraints	Meet constraints established to preserve national interests?
International treaties and less formal agreements	Meet applicable treaties and national and international laws governing space activity, the environment, and peaceful uses of outer space?
	Meet less-formal agreements established between nations, based on mutual self-interest?
Program scale	Enable participation in programs of a scale beyond domestic capabilities?
Program stability	Increase program stability?
Program risk	Decrease program risk?
Management regime of partnership	Lend itself to a management regime within which partners can work together?
Confidence in partnership	Instill confidence, from a political, technical, managerial, cultural and personal perspective, that the partnership can proceed and succeed?

Group 2: Material benefits	i.e. Does the proposed cooperation..
Financial	Meet financial reasons for establishing the partnership, such as shortage of national funds, cost sharing, return on investment, and economic survival?
Industrial development	Promote industrial development of partnerships to establish, maintain, or enhance competitiveness, market access and share, and technology base?
Access to expanded knowledge and skills base	Achieve an enhanced knowledge and skills base that enables creation of new capabilities?
Access to benefits of space (products/services/infrastructure)	Provide new or additional access to benefits of space, such as products, services, and social and industrial infrastructure?
Niche capabilities	Allow for the establishment, maintenance, or enhancement of niche capabilities?

After applying all the criteria the final call must be made considering the overall value of, and the effort involved in, concluding the partnership, i.e. do the benefits of the proposed cooperation:

- Provide adequate value from a return standpoint?
- Justify the effort of making the programme international?

To confirm the validity and applicability of the criteria developed, the Working Group ran two test cases; one examined a government-sponsored, industry-led program to develop a follow-on commercial global navigation satellite system, and the other concerned a government-led space science/exploration project. In the opinion of the Working Group, the two test cases realistically demonstrated that the application of the criteria provided a method for systematically assessing a potential partner's position on the international implementation of a specific initiative.

3. Working Group # 2: Using Space Assets for Disaster Management

Space assets have historically been developed for a select group of user communities, generally for military or scientific applications. The 1990's have seen this focus broaden to much larger communities, a trend that is likely to increase as new commercial applications are brought into the market.

Today space-based systems regardless of their primary purpose or owner/operator are becoming, or have the potential to be, seamless and useful for applications not originally foreseen. Also, we are beginning to see the utility of combining several different systems to satisfy an entirely different task. Disaster management is one activity that can benefit from the combined use of communications, Earth observation and position location systems. However, one problem facing many potential users and operators of multiple space-based assets, and their ground-based value added infrastructure, is that their owners/operators could be a combination of the public civil and military, and private commercial sectors. This is particularly true for those providing disaster management services.

Disaster management has the potential to be a "new space market". Disasters whether natural or contrived are not welcome events; however, they are a reality. They encompass the results of oil spills, floods, volcanic eruptions, hurricanes and tornadoes, creating civil unrest, mass refugee migrations and much more. Both the private and public sectors fund disaster management. Consequently, cost-effective management and containment of disasters is of concern to all.

Given the exceptional space assets currently available to manage disasters, the large number of coming services and the unique nature of space capabilities, it is perhaps surprising that space assets are not called upon more frequently to play an essential role in managing disasters. An initial assessment, by the Working Group, revealed that the world's disaster managers are unaware of the range and scope of the services space could offer. For example, during the past year Radarsat International, who are responsible for commercial applications of Canada's remote sensing satellite, Radarsat-1, have provided images to aid in the management of several disasters such as an oil spill off the Welsh coast, refugee movements in Zaire and the flood of the Red River in North Dakota, USA. Satellite-borne synthetic aperture radar is particularly useful since imaging is not affected by rain or cloud cover so information can be provided in near real-time. It is instructive to note that these images were provided, most often as a public service, through Radarsat International's initiative, the disaster managers being unaware of the potential or availability of this capability.

At present, no mechanism exists to allow efficient and simple access to space assets by the disaster management community, nor is there any clear articulation of the specific needs of the disaster management community,

which would enable the owners of space assets to develop resources that cater to these needs.

The Working Group suggested that to facilitate dialogue between users and service providers an organization should be established responsible for researching the disaster management community's needs and applications of existing assets, and for suggesting new applications. Such an organization would also allow economies of scale and rationalization of current space asset use. Furthermore, the Working Group postulated that if structured as a value-added service provider, such an organization could be a business, marketing services to governmental and non-government disaster managers throughout the world.

The Working Group's report provides a practical action plan to promote the use of space assets for disaster management. It includes the establishment of points-of-contact to promote awareness related activities and help promote limited pilot projects. A three phase approach is recommended: Phase 1 would be primarily the phase during which the requirements would be established and the disaster management community made aware of the capabilities of space assets to help their efforts; Phase 2 would include limited pilot projects to test concepts; and Phase 3 would be the refinement and operation implementation phase.

4. Working Group # 3: International Cooperation in Space Transportation

The high cost of access to space was initially addressed at the second workshop of the series, in December 1994 (see reference 4). At that time the Space Transportation Working Group concluded that:

- A dramatically expanded commercial utilization of space would not be achieved without routine assured low-cost access to space
- National/regional programmes had a meager chance of developing completely new space transportation systems in the near term
- The probability of a commercially successful, fully reusable system being developed without government participation was very low
- In the then current global fiscal environment, it was unlikely that any single nation or regional organization could afford to develop a commercially viable, fully-reusable system in the near term

- The then existing, and predicted, space launch market did not provide sufficient economic incentive to attract venture capital for the development of a fully reusable or alternative technology launch system.

When the third workshop took place the basic premise developed in 1994, regarding cost reductions that would enable new users to join the market and expand the customer base, was still valid. However, during the sixteen month interval between the two workshops much happened to change the global outlook on access to space. In particular:

- A combination of government and private funding and international collaboration had resulted in a number of upgraded or new expendable launchers
- Two new programmes aimed at low-cost space access had been initiated in the United States (EELV and RLV)
- Several small commercial launch vehicles had come on the market and spaceports to support them were proliferating
- Steady progress in space transportation technology was being made
- Market surveys were predicting a rapid expansion in launch demand, particularly if launch costs were to be reduced.

There was also a recognition that, in the important area of manned space flight, transportation systems were aging and would need to be replaced with new, lower cost, more efficient technology. Given the worldwide downturn in government funding of space activities, the magnitude of such an effort and the potential benefits that could result for all nations, international collaboration appeared to be a prime candidate for satisfying this need.

It was against this background that the primary goal of the Space Transportation Working Group at the 1996 Workshop was established to be the determination of the role that international cooperation could play in making major reductions in the cost of access to space, sufficient to facilitate the entry of new, non-traditional users. In the course of its deliberations, the Working Group developed a set of findings relating to the cost of access to space and its relationship to international cooperation. Only those of relevance to new space markets are addressed here.

The cost of access of space is inhibiting its commercial exploitation. Even in the highly successful telecommunications area it limits the rate of growth, adds to the cost of services and reduces the number of financially viable participants. Several classes of commercial and government applications in

such fields as Earth observation and navigation have experienced only modest expansion and the limited activity in microgravity science, materials processing, and manufacturing in space remain heavily dependent on subsidies by governments.

If very low cost, highly reliable space transportation could be achieved, new market opportunities would be fostered, not only in these areas, but in a host of non-traditional applications such as space tourism, energy delivery from space and, perhaps, hazardous waste disposal. Many of these applications can be viewed as global needs requiring global solutions and, as such, are prime candidates for involving international cooperation in the improvement of the enabling transportation infrastructure.

This should not be interpreted as implying that the goal of cooperation would be the development of a single international space transportation system. Commercial users need to have reliable and robust access to space. They must have the opportunity to choose from a number of alternative launchers and not be forced to depend on a single means of access to space. Furthermore, they will expect some form of involvement in formulating the requirements to be met by future launchers, based on their level of satisfaction with current systems.

Competition in launch services will determine the extent of international cooperation in the commercial sector and will influence the extent of cooperation among competing nations. Where existing government-supported national systems have an adequate market share, the opportunities for international cooperation are limited. International cooperation may be sought to off-set the government cost of new systems and for expanding the market share of existing systems, if compatible with national political goals. Most growth in launch vehicle systems and services, however, will be commercially driven and international cooperation will be dictated by the business interests of investors, to the extent feasible. National policies will have to be structured to permit this growth, if it is to occur. The best prospect for international cooperation in system development is in the longer term, where new technologies could lead to totally new launch systems.

The Working Group determined that international cooperation at the commercial/industrial level has already contributed significantly to the expansion of available launch services and has contributed somewhat to the reduction in cost of access to space. Further international cooperation, especially where it is initiated and supported by government, could lead to dramatic cost reductions, perhaps sufficient to facilitate the entry of new, non-

traditional users (e.g. entrepreneurs, developing nations, non-space related public agencies and small private businesses), while also reducing the cost of use by traditional users.

Cost reductions of 50% or more are desired by traditional users, whereas immediate reductions by a factor of 10 or more are necessary before a significant expansion of space activity will be realized. Technologies that permit an order of magnitude cost reduction are under consideration, while some technologies that could result in two to three orders of magnitude reductions have already been identified.

If international cooperation is to help in achieving these required launch cost reductions, the most significant pre-conditions are:

- The terms of multilateral cooperation should support industrial, national, and regional policies for independent access to space
- Successful multilateral cooperation of government-supported programs is enhanced by striving for equal status among stakeholders, with effective representation in the decision process and without asserting preeminence
- Multinational cooperation must allow partners to pursue national economic policies
- National policies must encourage commercial international cooperation and technology sharing, to enable further cost reductions

To achieve these pre-conditions and to align participants for a significant increase in international cooperation, involved governments must review the relevant elements of their respective policies and take appropriate action. This would include:

- Moving from a focus on bilateral agreements, which restrict market freedom, to multilateral agreements, which facilitate a free market, with a goal of eliminating agreements restricting a free market
- Implementing the Missile Technology Control Regime (MTCR) agreement to achieve both non-proliferation goals and encourage a free market
- Removing barriers to the exchange of data necessary to facilitate international cooperation, for example through pre-approved protocols.

The opportunities for international cooperation, especially with an initial priority of technology development for advanced or alternative technologies, are enormous and the payoff for all involved will be great. The next five to twenty five years could witness an explosive expansion in access to space. The

resulting space ventures will be remarkable by any standards if these actions are taken and implemented in a true spirit of international cooperation.

5. Working Group # 4: International Space Station Utilization Strategy

"The successful implementation of the International Space Station, as the largest science and technology project in history, will deeply influence all future internationally cooperative projects. It is of crucial importance, therefore, that the immense capabilities of the Space Station be utilized to the fullest not only by scientists, but also engineers and entrepreneurs worldwide." These were the opening remarks in the report by the Working Group that was tasked with developing an International Space Station Utilization Strategy.

The Space Station may not, in many people's minds, be viewed as a potential new space market. However, most of the fifteen countries involved as partners in the Space Station are looking at ways to commercialize, through short or medium term leases, at least some of the Station's user accommodations, either within their own countries or in countries that are not contributing Partners. Each of the five Partners; the USA, Europe (through ESA), Canada, Japan and Russia have "rights" to certain percentages of the Station's user accommodations, and the Agreements governing the project allow for non-partner use, through any of the five Partners, as well as Partner use.

The Working Group concluded that to take maximum advantage of the Space Station, its capabilities must be broadcast much more widely to the individuals, institutions and private sector organizations who could benefit from the Station's microgravity environment, availability to extremely low vacuum conditions, and an orbit permitting unequalled field of vision allowing measurements of the Earth, its environment, the solar system and the cosmos.

While research opportunities on the Space Station have been reasonably well communicated to the science community, this has not been the case with the engineering community. The development of new technologies for industry in space, as well as for terrestrial applications, holds much promise. Though most Partners are reserving a portion of the Station's user accommodations for technology development, science and commercialization activities, little is being done on an international basis to promote such use.

Thus, the Space Station Partners should establish a Multi National Space Station Utilization Promotion Initiative (office), staffed by a small group of experienced professionals, with the objective of: augmenting the individual

efforts of the Partners in promoting and coordinating Space Station utilization; broadening the scope of scientific and technology disciplines represented; and seeking and encouraging private sector investments in entrepreneurial ventures. Further, steps should be taken by the Space Station Partners to encourage and facilitate entrepreneurial ventures for privately funded facilities or services, in return for use fees, in support of Space Station utilization and its growth, which could include: multi-user/general purpose facilities, to complement and integrate those provided by the cooperating agencies; infrastructure elements for enhancing Space Station capabilities such as additional power sources, communication links, new modules, or ground-based activities; and opportunities for the utilization of the Space Station on a commercial basis for products and/or processes that may develop into viable businesses.

The Working Group concluded their report with recommendations for a minimum set of policies and procedures that should be established to guarantee fair competition.

6. Conclusions

Using space assets for disaster management will open new avenues to relief efforts and disaster preparedness and prevention activities. It is essential, however, to ensure that disaster managers are fully aware of the possibilities offered by space assets, and that they are able to access them in an efficient and straight forward manner. The subsequent establishment of a permanent commercial or institutional bridge between the user community and the service providers will bring technology closer to those whom it is designed to serve.

It is undeniable that many of the potential new and innovative space markets will only occur with lower cost access to space. If the launch industry can achieve at least an order of magnitude cost reduction, new space markets may materialise that hitherto have been prevented from happening due, almost exclusively, to the prohibitive cost of getting out of Earth's gravitational well.

The success of the International Space Station will profoundly influence all future international cooperative ventures in science and technology. Therefore it is crucial that worldwide participation in its utilization by scientists, engineers and entrepreneurs be achieved to the fullest extent possible. The operation and utilization of the Space Station may well prove to be an evolving new space market opportunity for several diverse industries.

Clearly, international cooperation will continue to play an important role in a wide variety of space activities.

A limited number of the Workshop Reports are available from the AIAA. To request the Reports, please contact Mireille Gerard, AIAA, 1801 Alexander Bell Drive, Suite 500, Reston, VA 22091, USA. Fax: +1 703 264-7551. E-Mail:Custserv@aiaa.org

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Space Activity at the Threshold of the 21st Century: A Geopolitical and Geoeconomic Perspective

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Abstract

After the Cold War the space programs of individual nations and world-wide space activity had to learn the rules and the laws of economics since this is the only reliable means of survival in conditions of a radical change in world economy and international relations. The principles and procedures of resource allocation for space activity have been drastically revised. There will be no "crash" space programs of the "Apollo" and "Star Wars" type in the foreseeable future. National and international space projects will have to prove their competitiveness across the board in real terms of economic efficiency. A perspective on economic benefits and economic incentives for space activity in conditions of the growing world market of space goods and services is put forward in this paper.

The beneficial impacts of space activity reach into many avenues of everyday life of the world community. They are divided into tangible, which may be calculated by cost-benefit analysis and other economic methods, and intangible, which have no apparent applicability to practical use. The utilization of space technlolgy for purposes other than that for which it was originally developed has become one of the most economically useful, socially beneficial and politically challenging endeavours of the post-Cold War history of humankind. The demand for space goods and services grows at a rate of not less than 5% annually and the total annual return in this area is estimated to amount to about 100 billion dollars by the turn of the 21st Century. Space activity is not a luxury; it offers important economic paybacks, which will grow as world space markets will be developed by the joint efforts of governments and the private sector. The complex interdisciplinary essence of space activity makes it necessary to explore future space markets in the framework of at least three interrelated dimensions: economic/commercial, political and legal. Successful business strategies for space programs as well as economic incentives for the further commercialization of space will require due account of both the diverse aspects of space infrastructure and the complicated socio-political environment in which world markets of space-related goods and services will develop.

1. Introduction

When placed against the background of the most significant advances made by man throughout the history of civilization, space activity is rightfully claiming an outstanding position. After many centuries of speculations about ways of reaching the Moon, the planets and distant worlds, with the launch of Sputnik 1 humankind started its endless road into space. The exploration and the practical use of outer space has already proved to be more than just the development and practical use of technical assets - launchers, spacecraft, on-board equipment and ground systems - which make it possible to overcome the Earth's gravity and to implement manned and unmanned experiments in outer space. Step by step contemporary space activity has emerged as a pervasive, interdisciplinary system, whose socio-economic,

political, cultural and intellectual elements are manitest in virtually every aspect of life of the world community.

As advances in science and technology visibly improve human society, more people agree that the progress of civilization is concieved as the triumph of growth over inertia and decay. In this context our presence in space is not an unnatural or presumptuous exercise, but an acceptance of our role as custodians of our own evolution. Motivated in its initial stages by the search for new knowledge, prestige, military security and ample contributions to the progress of humankind, the exploration of space has grown rapidly and now embraces the most advanced realms of engineering and technology, physiology, biology, the sciences concerned with relating man and dynamic systems and machines, the environmental sciences, the behavioural sciences, communications, navigation, astronomy, geology, meteorology, and new tools and techniques for managing large programmes, politics and international diplomacy, budgeting and high finance, almost every kind of manufacturing industry and a wide range of the social sceinces. Former NASA Associate Administrator R.Seamans warned: *"To integrate so many facets of human endeavor into economically viable, close knit and fast moving programmes calls for multiple decisions of great magnitude, yet in many cases major decisions have to be taken before all the factors affecting them are fully known."* (Reference 1).

On the Soviet side the rich creative legacy of outstanding thinkers, scientists and engineers, which was a solid foundation for the breakthrough into space to be used as an instrument of the long-term progressive development of civilization, was forcefully reduced to a primitive weapon of class struggle for a socialist future for all the peoples and nations of the world. The leaders of the command and administrative system in the Soviet Union considered their "space firsts" as convincing proof of their country's competitiveness in the world arena, primarily in the military field. On the American side the dominant motive was to deny outer space and the planet Earth to the spread of world communism. The combination of these two national approaches to the exploration of space was far from encouraging for the progress of the civilization.

Only the two post-World War II superpowers - the Soviet Union and the United States - had the scientific and technological potential, economic infrastructure and other elements of national wealth to answer the challenge of the space age. Unfortunately these nations were divided by cardinal contradictions of an ideological and politico-military nature, involved in a large-scale arms race and engaged in competition for the domination of the

world. In the atmosphere of such irreconcilable rivalry, "space technology as translated into industrial capacity and military hardware became a major indicator of national prestige and power" (Reference 2). It was practically impossible to implement the forward-looking and rational prescriptions of the experts of the UN Committee on the Peaceful Uses of the Outer Space, who claimed that the "full benefits of outer space can be realized only when nationally and internationally an appropriate culture can be created... The greatest cost-effectiveness of the uses of outer space occurs through large scale applications rather than those of limited scope" (Reference 3).

Against such a socio-political background both the geopolitical and geoeconomic perspectives of space activity during the Cold War were far from favourable. Space nations were anxious to limit the practical use of space technology largely to their own national interests, did their best to deprive their adversaries of the access both to outer space and to information from their space assets. The legacy of the first decades of the space age may be qualified as only partially productive, full of overlooked opportunities, both for the space nations themselves and the world community at large.

2. Geopolitical Factors Dominating Post-Cold War Space Activity

Almost worldwide rejection of military superiority as a rationale for foreign policy, economic development and space activity brought about cardinal changes in national space policies and methods of implementation of space programs. The disappearance of the Soviet Union as a viable military threat has precipitated the most dramatic reduction in defense spending in more than forty years. In many countries of the world, structural reduction of defense investments is at hand. Although advocates of space activity argue that "defense and space programs enjoy many of the same technical and management characteristics and that increased investment in space programs offers important political, economic and security benefits in an increasingly interdependent world" (Reference 4), the second half of the 1990's witnesses steady reductions of national space budgets accompanied by substantial drops in aerospace employment in the majority of the space-faring nations. In the foreseeable future one can hardly expect "crash" programs of the "Apollo" or "Star Wars" nature. Space assets will continue to serve the interest of national and international security. But the notion of security undergoes rapid and sweeping changes. The availability of weapon arsenals and a nation's ability to implement force beyond its territory are being replaced by a complex system of factors, which, in combination, show in any particular situation the state of comprehensive security of a state, region or/and world community at large

(Reference 5). There is not a single aspect of comprehensive security which can be efficiently maintained without the use of information from space and other elements of valuable experience from national and international space programs.

In a geopolitical perspective the concept of reconnaissance from space gives way to the use of national space assets more as a "common heritage" of humankind serving the cause of survival, integration, human rights and cultural diversity of the world community. For example, the potential for environmental degradation, whether induced by natural or human causes, to exacerbate other elements of conflict within nations or regions leads to the lack of environmental security. A host of environmental problems throughout the world can lead to increased social and political tensions within and between nations. Unique information acquired from space could improve the world's ability to discover impending problems before they become serious.

Activities in space should be organized along the avenues of greater international coordination with a growing number of complex space ventures on a multilateral basis. More common goals for space activity, formulated at high political levels, combined with the well-developed strategies of individual nations and groups of states create favourable conditions for increasing economic efficiency of national and international space programs, for broader economic payoffs of space projects.

Mutual trust, selective interdependence, shared leadership and the greatest possible contributions to success in joint undertakings are considered the essential foundations of future large scale space efforts serving the interests of many nations and bringing in feasible economic returns from investments in space projects. Both the governments and the leaders of national and international space agencies and organizations share the view that collaboration is the only productive option, pooling the scarce financial and technical resources alloted to space activity since the end of the Cold War. The trends towards sustainability of world-wide space activity combined with positive changes in world politics and international relations produce favourable conditions for the expansion of new space markets and the improvement of economic incentives for the further development of space technology.

3. Towards Economic Rationale for Space Activity

The beneficial impacts of space activity reach into the everyday life of the world community. The flow of new knowledge, innovations and high

technology products as well as secondary ("spin-off") results from space programs to non-space sectors started with the beginning of the exploration and practical use of outer space. Major advances in science and technology, gained in the course of space activity, affect in a positive way the national productivity and industrial competitiveness of the space-faring nations. Space programs continue to be a leading source of new technology, since they demand extraordinary technological inputs and diverse innovations, some of which are readily transferable and provide "a wellspring of know-how for new applications tomorrow" (Reference 6).

Thousands of companies in many countries take advantage of the technology, transferred from the space sector of the national economies to develop tens of thousands of spin-off products and processes. Such spin-offs represent a substantial and growing dividend on the investments in space activity. Whereas some spin-offs offer only moderate benefits, others have a large impact on the economy, spawning new companies and creating new jobs, which is a strong incentive for stable economic growth.

Estimating the economic benefits of space activity and the development of feasible criteria of its economic rationality are complicated. The known efforts of different research teams to estimate the economic impact of investments in space produced only partial success, since they could not put forward a comprehensive methodology which could be applied to the space program as a whole. This point may be illustrated by a conclusion from the Chase Econometric evaluation of long-term productivity effects of space-related R&D spending:

"Such spending increases the rate of technological progress, which permits a greater rate of capacity expansion and also lowers the rate of inflation, hence increasing the real purchasing power of consumers. In the absence of technological progress, wage rate increases are not offset by productivity gains, and thus prices increase by the same proportion. This actually reduces real disposable income, since consumers are faced with a progressive tax schedule which is denominated in current prices. Higher prices also result in inadequate accumulation of capital consumption reserves, since these reserves are based on historical rather than replacement costs. The significant long-range benefits accrue to all sectors of society when the rate of productivity gain is increased" (Reference 7).

A well-known American economist proposed the following classification of the economic consequences of the space effort, deriving from the public

investment of national resources: *"First, there are consequences of annual spending. This money goes through many channels to different industries, services, and regions of the country, ultimately back to some taxpayers. Second, in pursuit of space missions, entirely new products are created, be they new instruments, new materials, etc.. Some of these could also be had without a space project if one should have defined a need for them and created the necessary pressure to produce them. These new technologies exert a favorable impact on the economy: they create new skills and increase productivity; they produce a net addition to the nation's industrial capabilities. Third, some parts of the space program have a direct impact on the economy. Programs and applications as those related to communications, the sensing of resources, and the processing of materials in space have made great and will in the future make even greater contributions to the national economy. The returns to these applications may be expected to accelerate as space becomes more accessible through the space shuttle and the tug. Fourth, space missions have and will generate important scientific results. This will scarcely produce immediately more economic hardware for the marketplace. Others will have more predictable, though possibly distant practical implications.Thus, anyone who has an expectation of necessarily quick industrially significant payoffs from basic scientific discoveries in space has no proper appreciation of the complexity of the matter and of the inheritent difficulties of carrying a new scientific discovery over into some practical application"* (Reference 8).

In the post-Cold War socio-political environment, space programs are implemented by the joint efforts of the following actors: government agencies responsible for the development and practical use of space technology in the interests of national security; government agencies responsible for the development and application of civil space technology; and the nongovernment private sector. At present the scale of the commercial application of space technology is determined mainly by the degree of participation by the private sector, which can only expand into space markets with the support of national government and the leadership of the national space program. Attractiveness of information, telecommunications, and observations as a commercial focus of space is responsible for substantial growth in private commercial space activity. Governments, industry and financial groups are showing increasing interest in the commercialization of space technologies and projects. In particular they are keen to diffuse the operation of some types of space technology to a wider range of clients. These may include government agencies, state and local authorities, private business and individuals. Their use of commercial space technology might include the leasing of space systems or paid access to information obtained by these systems.

The pattern of investment in space activity has changed dramatically in recent years. *"One of the most obvious choices for stimulating continued space investment is in economic development and eventually private sector commercial use of space resources. Virtually all space investing nations have shifted management goals from using the industrial base for producing space hardware for their governments use to using the government to encourage private risk taking in space for private profit"* (Reference 9).

Commercialization cannot embrace the entire space program. As of the mid-1990's the major areas of space commercalization are the leasing of launch vehicles and launch services, telecommunications, remote sensing and materials processing in microgravity. This means that some areas of space activity will have to wait, as was the case during the Cold War, for government support and the sharing of profits with the commercialized sectors of space programs. Growing commercialization of space activity produces new economic incentives for national and international space programs, and contributes to their growing sustainability. But despite such positive trends some sectors of space activity remain inaccessible for a cost-benefit analysis. Their contributions to the progress of society should be treated as intangible and estimated by "non-economic" criteria involving political, social, educational, cultural and other humanitarian factors. Because of the interdisciplinary essence of space activity these factors cannot be disregarded in the estimates of the overall value of national and international space programs. And though the national security and defence motivations no longer dominate the rationale for space activity, economic criteria alone cannot be an adequate means of measuring the success of space efforts.

4. Concluding Remarks: Looking into the Future

"Our earthly destiny is to organize the Earth, achieve perfection and settle throughout the solar system", wrote the founder of space flight theory, (see K.E. Tsiolkovsky in his pamphlet "Gratitude", Reference 10). These thoughts were expressed long before the space era, but they may be looked upon as an original long-term forecast for space activity. Exploration of the Universe by humankind may be considered rational only when the world community will succeed in putting its own planet in order, in amending the errors of the past, in building on Earth a harmonious and sustainable civilization serving the interests of the present and future generations. Space activity for the foreseeable future will grow only if it is pursued from the solid foundation of an efficient economic infrastructure of the planet Earth. One cannot expect the rapid development of a world market of space goods and services without a

similar improvement and optimization of national, regional and world economies and an expansion of domestic and international markets of non-space goods and services.

The future of world-wide space activity as well as the improvement of the economic efficiency of space projects is connected with the prospects of international cooperation in the exploration and practical use of outer space. Economic factors create favourable conditions for the development of a "common market of space goods and services", accessible for all the states and nations of the planet. But a geoeconomic perspective of space activity at the threshold of the 21st century is not limited only to the trends and market forces which will determine the world-wide exchange of space goods and services. Recent calculations show that the demand for space goods and services grows at a rate of not less than 5% annually and the total annual return in this area is estimated to amount to about 100 billion dollars by the turn of the 21st Century.

As Russian economists warn, *"investments in any branch of the economy, science and technology or in the services consist not only of expenditures on research and production capacities. Product distribution on the domestic and world markets needs to be systematically and thoroughly thought out in order to provide profits from capital turnover. The productive capacity of the space program is the totality of technological systems and equipment intended for exploration and practical use of space that can be produced and put into operation within a year at the space sector's enterprises"* (Reference 11).

With due account being taken of the complex nature of space activity the following incentives for the future support of economically feasible space programs and projects may be proposed:

- Broader participation of governmental agencies, private sector and public entities in planning and implementation of space programs;
- Constant search for new customers for space goods and services as well as for other useful results of space activity in domestic and international markets;
- Optimization of mechanisms of transfer of innovations and technology, including spin-offs, from space programs to non-space sectors of the national economy and the world markets;
- Measures aimed at the enhancement of international cooperation and integration, as well as at developing common infrastructures for pooling efforts in space on regional and global levels;

- Improvement of the norms and mechanisms for elaboration and implementation of a rational policy of partnerships in space;
- Further development of fundamental and applied research on the economic problems of space activity.

Successful business strategies for sustainable space programs as well as economic incentives for further commercialization of space and rationalization of space activity will require due account to be taken of both diverse aspects of the space infrastructure and the complicated socio-political environment in which world markets of space and space related goods and services will develop in the future.

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The Economics of the European Space Industry:

The Impact of the European Military Space Market on Structure, Conduct and Performance

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Abstract[1]

This paper examines the European space industry and the causes and effects of its recent restructuring. Following this analysis, the effects of a newly emerging European military space market in the competitiveness of the industry in commercial product markets are presented. It is shown that these effects are positive and sensitive to the demand characteristics of the European military space market, as well as the size of the joint economies in production of military and commercial space products. The policy implications of this are that the cooperation of the WEU and the ESA in establishing the required technical specifications of the contracted products is beneficial for the competitiveness of the European space industry.

1. Overview of Cost and Demand Characteristics of the European Space Industry

With the diminishing national security considerations brought on by the end of the Cold War era, space markets became increasingly commercialized, and simultaneously the prospects of declining defence contracts in the US and Europe forced the major aerospace firms to shift their attention from the highly profitable, but expected to diminish, military market, to the expanding commercial markets. Examples of market and product de-classification are found in the remote sensing market where a continuous tendency for higher resolution commercial images is experienced, as well as the increasingly extensive use of G.P.S. for commercial purposes, such as runway approach for commercial airliners, etc.. The end of the Cold War also contributed to the construction of the International Space Station and some resulting commercial capabilities, such as microgravity experiments and production.

As far as the military space markets are concerned, the picture is quite different. While in the USA, Russia and Ukraine there is a general tendency to diminish the respective markets, in Europe, through the West European Union (WEU), the prospects for the military space market seem promising. Helios-1, the first major European Intelligence-Earth Observation (E/O) satellite was

[1] This paper was written for the 1997 ISU symposium: "New Space Markets". The complete version of this paper is available on request.

launched, evidence of the WEU's commitment to expand its military space capabilities.

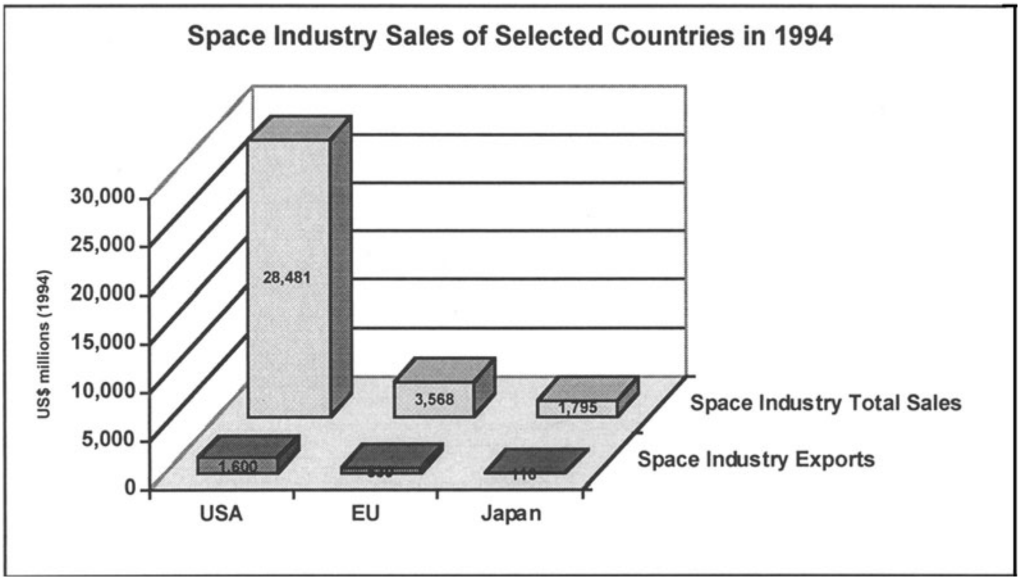

Figure 1. Space Industry Sales of Selected Countries in 1994
Data source: Reference 1

In 1994, the EU's space industry's total sales consolidated at EU level were close to US$(1994) 3.5 billion, placing it after the US space industry, with the Japanese space industry sales in third place (See Figure 1). The public sector is predominant, with 57% of the total demand going to government civil markets, mainly through national space agencies and the ESA. Military space markets account for 9% of the total space industry sales (See Figure 2). The commercial market seems quite developed, with 34% of the total, mainly due to the success of the Ariane launcher, the Arianespace consortium and the telecommunication satellites market. The military space market is fairly small, compared with the military component of the overall European aerospace market, which accounts for almost 50% of the total. This is evidence of the dependence of the

EU countries on the US within NATO in this strategic sector. The overall civil/commercial orientation of the EU space industry is also reflected in the relative size of exports as compared to the US and Japan. Within the EU, the countries with the most developed space industry are France, with close to 40% of the total sales (with the inclusion of Arianespace this percentage goes up to 60%), Germany with over 15%, the UK and Italy representing less than 10% each.

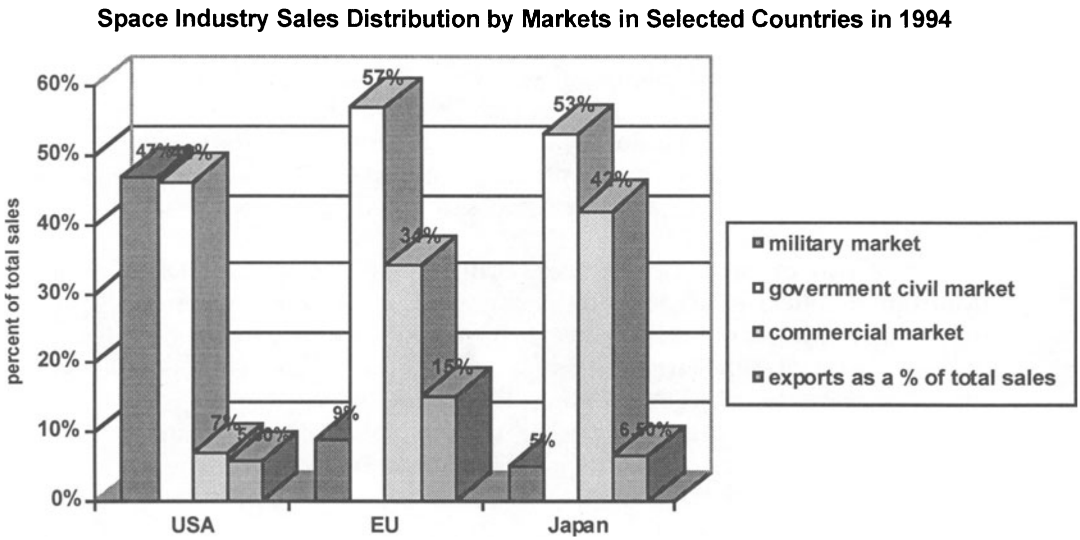

Figure 2. 1994 Space Industry Sales Distribution by Markets in Selected Countries
Data source: Reference 2

Despite the comparative advantage of the US space industry in most space products over the EU and Japan, due to long production lines and substantial economies of size, the US space industry seems to be government market oriented, with relatively small commercial sales. For example the EU with the Ariane launcher holds over 50% of the world's market for launchings for GEO commercial telecommunications satellites despite the greater experience of the US industry with at least four compatible launchers, with much longer production lines. The explanation of this rests with an inconsistent US space

policy in the 1980's when the government declared the Space Shuttle as the main launcher, thus closing down most other launcher production lines. The "U" turn of the US government after the loss of the Challenger gave Ariane a substantial share of the commercial launches market, a place which is maintained.

As a result of the specific cost characteristics of the space industry and the expanding commercial markets, both in Europe and the USA there has been a wave of mergers and restructuring since the late 1980's. These industries, as the most developed in the Western world, are the major competitors for commercial products such as telecommunication satellites and launchers. A direct consequence of the presence of economies of scale/learning in the production of space goods is that the US high domestic (government) market has a cost advantage over the smaller European space industries. Cooperation of European industries in space and aerospace products has resulted in commercial successes in both areas, with the creation of Arianespace and Airbus, respectively.

The two major UK companies, British Aerospace Space Division and Marconi, involved in space activities, have merged with the French Matra, resulting in Matra Marconi Space. In Germany, through a number of recent mergers (MTU, MBB, Dornier), there is a virtual monopoly in the production of major space products by DASA. In addition to the above, there is also the long awaited merging of Aerospatiale or MMS with DASA to create a virtual duopoly in major space companies in Europe, with minor exceptions such as the Swedish Saab and the Italian Alenia Spazio.

At the economics level, the basic rationale for this increase in concentration of the European space product manufacturers industry is the following:

- Economies of scale, and scope and savings from overlapping R&D

The recent consolidation of the European space industry has the implication that, as the size of the European firms increases and their number decreases, the new firms will be able to exploit economies of scale and achieve the implied efficiency improvements necessary to compete successfully with their more sizeable US counterparts. In addition, duplication of R&D will diminish for the European industry as a whole and thus efficiency gains will be achieved.

These efficiency gains will tend to increase the overall profitability, a tendency reinforced by the lack of competition within the European markets,

especially the protected government markets. The model presented in this paper predicts that the prices of the European protected-government markets with no competition will be much higher and the output produced much lower than in the competitive commercial markets. This situation will be reflected in the profits derived by the two markets.

- Firm size as a barrier to entry into expanding commercial markets

Given the high potential of commercial markets, efficiency gains due to economies of scale and learning, the newly emerging high-size established firms will discourage any newcomer firm attracted by the growth in the commercial product-markets.

- Diminishing of transactions costs for integrated space products

Space product customers are interested in purchasing a complex product. For example, a telecommunications organisation needs a launcher, a satellite, a ground segment and coordination, insurance, etc.. If each product is provided by a specialised firm and they all merge, then not only transaction costs diminish but, most importantly, product specific investments by each merged firm will be undertaken due to reduced uncertainties about their partners. In addition any other competing firm, say, for launchers will discover that a satellite from such a merged firm will necessitate additional modification costs for its launchers.

The overall improvements in profitability and cost effectiveness for the European space industry from the recent restructuring allow manufacturers to improve their overall competitiveness. This should result in better and cheaper products for the commercial space markets, while the increased concentration of the industries will allow them to maintain high profits, especially in the protected government civil/military markets.

2. Effects of a European Military Space Market on the Competitiveness of the Industry in Commercial Markets

Given the cost characteristics examined in the previous section, the market structure and the high concentration of the European space industry, a model is presented to illustrate the effects of the newly emerging European military space market on the competitiveness and profitability of the European space industry.

Based on European Commission time series data for the aerospace industry, we observe that, despite the small share of the European space sector in the total European aerospace industry turnover, its contribution has steadily

increased from 3.1% of the total turnover consolidated at EU level at constant 1991 prices in 1980, to 8.5% in 1994 (Reference 2). Of the other three sectors, Aircraft and Missiles, Engines, and Equipment, only the last one stood higher in 1994 than in 1980. As far as the total European space turnover is concerned, it has increased from ECU 24,875 million in 1980 to ECU 32,710 million in 1994, indicating an average growth rate of just over 2% for the whole period, despite the last four years' "growth" being negative.

These figures indicate that the space sector is rapidly expanding in size compared to the other aerospace industry sectors, with the military space component unstable, but reaching its peak in 1994 after a continuous 4-year increase (Reference 2). The European military budgets as a proportion of the civil budgets for 1993-'94 were near to 20% and at similar levels for 1995-'96. In current prices both military and civil budgets in Europe increased from US$ 1,000 million and US$ 4,600 million, respectively, in 1994 to US$ 1,100 million and US$ 5,100 million, respectively, in 1996. The increases in military space budgets and turnover in Europe are largely due to European nations' collaborative efforts and are expected to be sustainable in the next century, given the commitment of the WEU to military space (Reference 3).

Based upon the work of Cooper et al. (Reference 4) and Bulow et al. (Reference 5), a market model has been constructed. This model assumes the existence of a firm (firm 1) which is a monopolist in one market (the domestic/military market) and a duopolist with another firm (firm 2) in another market (the commercial market).

The monopoly market in the model represents the newly emerging protected European military space market. The expectation that the European military space market will be a near monopoly for the European space industry manufacturers is supported from the increased concentration of the industry, and evidence from a number of sources which suggest that firms awarded government contracts in general, and defence contracts in particular, earn higher profits than firms operating in competitive, commercial markets. A factor contributing to this situation is the direct or indirect preferential treatment by the public sector of the domestic industry, and the preferential treatment which this receives, as opposed to overseas competitors. Such an example for the European space sector as a whole is the "juste retour" industrial policy followed by the European Space Agency.

The duopoly market is the market for commercial space products, which is international in nature and includes the commercial space markets of the USA,

Europe and the Rest of the World (RoW). As the model illustrates, a European military space market will tend to improve the competitive position of the European space industry in the commercial markets with respect to its main competitor, the US space industry. The last has enjoyed a large domestic military and civil space market ever since its first steps, based on which it has established itself in commercial and other space product markets.

This paper indicates that the European space industry will be able to take advantage of a European military space market to improve upon its competitiveness. The results of the model, however, rely largely on the specific cost characteristics employed, namely the existence of economies of learning in the production of space products and the economies of scope.

The policy implications are that WEU / ESA cooperation in space and the resulting harmonization in product specification appears to have beneficial effects for the European space industry, resulting in procuring as technically similar products as possible and avoiding duplication of R&D. The production of technically similar space products for military, civil and commercial markets will allow the European space industry to exploit the economies of learning from long production lines, while non duplication of R&D means that existing budget appropriations and firm R&D allocations will ensure that the European space industry will keep up with the rapid technical progress which characterizes space products.

Finally, the results of the model indicate that an increased domestic demand due to subsidization of the monopoly product will result in an increase in its price, a decrease in the price of the duopoly market product and an increase in the profits of firm 1. These results are in accordance with the outcome of a subsidization policy when there is only a duopoly market, examined in a number of empirical studies of the European commercial airline industry.

3. Conclusions

This paper is divided into two parts. In part one, the cost characteristics of the European space industry manufacturers were examined, which along with recent changes in the structure of the markets, mainly through increased commercialization of space products, resulted in a major restructuring and increased concentration of the industry.

Based on this, a model was constructed and simulated in part two to illustrate the effects of a newly emerging European military space market on the competitiveness of the European space industry manufacturers in commercial markets. The results of this analysis were that a European military space market will have positive effects on the competitiveness of the European space industry in commercial markets, while a less efficient outcome is observed in the military space market. These results are sensitive to the cost characteristics of the industry assumed, such as economies of learning and joint economies in the production of military and commercial products. A closer WEU - ESA cooperation is seen as having a positive effect on the latter.

In addition, the impact of subsidization of the monopoly (military) market product is examined, and is seen as resulting in an improvement of the position of the European space industry in the commercial market, and increased output produced for the military market, but at a higher price, and much higher profit levels for the European space industry manufacturers. Further research is required to allow for the impact of subsidization on incentives for the European space industry. Further research is currently under way to examine in more detail public policy issues for the European space industry, in particular, the need to correct for monopoly inefficiencies, using an interventionist approach (such as subsidization and/or regulation), while taking into account the effects of such actions in the commercial marketplace.

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Changes in the Satellite Communications Industry as Seen by a Global Supplier

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Abstract

Formed in 1964, INTELSAT could be considered a veteran in the satellite industry. It did change over time and it is today the leading global satellite operator for commercial applications. But the series of changes presently impacting the industry are of a different nature, in speed and content, than those seen before. They are triggered by deregulation, a booming demand for new services, the deployment of new technologies, and the emergence of new industry participants.

These changes are felt by INTELSAT, by its owners and by its commercial partners at the same time. INTELSAT has elected to bring four types of response to these new challenges. 1) It focuses on a major line of business for Voice and Data Services providing global services on a non-discriminatory basis. 2) It also focuses on dedicated Video and Broadcast services. 3) It is reorganizing internally while at the same time evaluating the possibilities to establish a commercial subsidiary. 4) It designs new services through applied Research and Development and the deployment of new technologies.

1. Over Thirty Years of Satellite Communications Experience

1.1 Formation of the Organization as a Cooperative

Founded in 1964, INTELSAT is the world's largest commercial satellite communications services' provider. INTELSAT owns and operates a global satellite system, offering two major lines of services: Voice and Data, and Video and Broadcast. It provides telephone, television, and data distribution to billions of people on every continent in more than 200 nations.

INTELSAT was the first organization to provide global satellite coverage and connectivity, and continues to be the communications provider with the broadest reach and the most comprehensive range of service.

INTELSAT is an international, not for profit cooperative of more than 135 member nations, operated pursuant to sound commercial principles. The owners contribute capital in proportion to their relative use of the system and receive a return on their investment. Users pay a charge for all INTELSAT services. The charges are based on the type, amount, and duration of service. Any nation may use the INTELSAT system , whether or not it is a member of the cooperative. INTELSAT basically operates as a wholesaler, providing services to end-users

through INTELSAT reselling partners being in most countries with telecommunications operators.

1.2 Gradual Evolution: a "Series of Firsts"

The "series of INTELSAT firsts" show three aspects of the organization: It has traditionally been "technically driven"; it got involved early in television and broadcasting services; it kept meeting market needs through offering new services such as the transmission of Internet traffic. Here are a few of these "firsts":

- 1969: World's first global system, providing worldwide coverage.
- 1969: Television coverage of the lunar landing: audience of 500 million people around the world.
- 1974: World's first international digital voice communications service, a precursor of today's advanced digital networks.
- 1978: Coverage of World Cup Football matches to a record-setting global audience, estimated at one billion people in 42 countries.
- 1980: The first INTELSAT V spacecraft launches, implementing the first use of the dual-polarization technique.
- 1986: For the first time, broadcasters use very small, easily transportable Earth stations to transmit news feeds via the INTELSAT system.
- 1989: Launch of first INTELSAT VI spacecraft: the largest and most complex commercial satellites ever built at that time.
- 1992: INTELSAT and NASA collaborate on a historical space mission to retrieve and reboost the INTELSAT 603 spacecraft, stranded after a failed launch in 1990.
- 1992: Global television coverage of the 1992 Summer Olympic Games from Barcelona, Spain, to an estimated viewing audience of three billion people.
- 1995: Launch of high power INTELSAT VII satellites.
- 1995: Demonstrate global access to Internet services through satellite.
- 1997: Launch of new generation INTELSAT VIII satellites.

2. Present Situation

Today, INTELSAT satellites carry more than half of all international telephone calls, virtually all transoceanic television broadcasts, and domestic services for close to 30 nations. INTELSAT provides a variety of international, regional, and domestic telephone, broadcasting, and business services. The planned 1997 revenue is above 950 million $ (US). About a third of this revenue

is derived from Video and Broadcast services, and two thirds come from Voice and Data services.

This is made possible through a fleet of 24 high-powered, technically advanced geostationary satellites providing a wide range of services like:

- Public switched network services (PSN) from 64 kbps up to 155 Mbps for international and domestic traffic, including ISDN support; TDMA networking providing high digital connectivity, on medium density traffic routes; Thin Route On Demand services for low bit rate applications; Private Network Services including point-to-point and multi-point VSAT applications.
- A wide range of video services: Program contribution including raw news feeds from the field using dishes as small as 1.6 meters; Program distribution to gateway antennas, cable headends, DTH, CATV and SMATV; HDTV. Service duration may range from ten minutes to fifteen years or more.

INTELSAT is one of many satellite based telecommunication providers. In most parts of the world it is competing with national, regional or even global contenders. Some are international cooperatives while others are commercial companies. Many of the new actors in the market are focused, entrepreneurial companies or rapidly growing regional operators.

3. A Set of Major Shifts

The present situation is evolving very fast due to strong change drivers, such as:

3.1 Deregulation

In some parts of the world, such as in the UK or the USA, deregulation of the telecommunications industry was implemented many years ago. In some other parts, like the European Union, some South American or Asian countries, it is presently happening or happened very recently. Finally, there are also many countries which remain unchanged, with a dominant national telecommunications operator. The process of deregulation is driven by governments who put in place new laws and form regulatory bodies in order to "police" the industry on issues like Telecommunication Operator Licenses, Television Broadcasting Licenses, and usage of the Frequency Spectrum in

accordance with international agreements. This complex process varies from country to country.

Deregulation means for INTELSAT a change in the way that it conducts business because of the increased number of reselling partners in "deregulated countries", and because of increased competition in the market place. Deregulation also directly impacts the owners and major re-sellers of INTELSAT, i.e. the former "National Telecom Operators". These PTT and Telecom Operators restructure, internationalize, deploy new services and become more competitive, all at the same time. Satellite based communications are only one of the many issues which they deal with throughout the deregulation process; in many cases it is not a top priority.

3.2 Deployment of Digital Technology

The evolution of transmission technologies, with the deployment of digital technologies not only for voice and data applications but also for video transmission involving standards such as Frame Relay, ATM, SDH-Sonet, MPEG, DVB (Digital Video Broadcasting), allows the usage of the space segment to be optimized and makes it possible to offer more sophisticated network services. It also allows different types of traffic to be merged in the satellite transmission network which removes the technical differences among various types of services. It brings more flexibility to the users.

3.3 New Satellite Technologies

Many new or improved satellite technologies are now being made available for commercial satellite applications. This started years ago, with small antennas such as VSAT. We are presently seeing the move to more Ku and Ka frequency band use. Finally, low and medium Earth orbiting systems (LEO and MEO) start to be deployed. These should soon bring capabilities such as Inter Satellite Links (ISL) and on board switching for "smart networking". A whole range of new applications is becoming possible, such as high definition digital television (HDTV), worldwide mobile telephony, or high bandwidth Internet networking.

3.4 Booming Demand for New Services

The demand for telecommunications is booming. Developed countries now need high bandwidths as well as broadcast and multicast capabilities. These needs are driven by applications like multi-channel television broadcasts,

multimedia, Internet, or business applications like video-conferencing. At the same time, less developed countries feel a stronger than ever need for telecommunications in order to sustain economic growth. Needs to be covered range from basic voice services (for a numerous and dispersed population) to sophisticated tele-learning or tele-medicine and access to advanced services (Internet, multimedia) in remote locations. Satellite-based communications makes these services immediately accessible without any need for a complex and costly terrestrial infrastructure.

3.5 New Players in the Industry

New players are rapidly changing the way in which the market behaves. They increase the pace of the action, the overall competitiveness and the availability of new services. As many are focused, and target specific segment or even niche markets, they tend to succeed quite well, benefitting from their efficient dynamic, fast reacting structures. They sometimes get caught in funding or cash-flow issues. In order to avoid this, while still remaining focused on their core businesses, they tend to look for partnerships, joint ventures and cooperative agreements with other players in the industry. They also get involved in mergers and acquisitions.

4. Adapting to the Future

Being aware of these market changes, INTELSAT is adapting in many ways in order to remain a strong successful player in the industry.

4.1 Maintaining a Strong Voice and Data Business: Digital and Internet Solutions

It expands its service offering Voice and Data applications, mostly through the deployment of digital communications services such as TDMA for medium routes and Thin-Route-on-Demand/DAMA services for low bit rate, and through offering the suite of "Internet ready" products called @INTELSAT. The Time Division Multiple Access (TDMA) service is a solution for customers with high connectivity requirements, on medium density traffic routes (approximately 10 destinations with the equivalent of 100 voice channels). The Thin Route-on-Demand DAMA (Demand Assignment Multiple Access) service provides thin route instant dial-up global connectivity, typically for voice traffic. The billing is based on the number of minutes used. It makes this service a low cost, state-of-the-art digital offering.

The Internet offering *@intelsat* is a suite of products providing global access to the Internet by utilizing a wide variety of Earth stations - including VSATs. Each product addresses a specific requirement:

- *@intelsat*.backbone. High-capacity service for backbone connectivity between Network Access Points.
- *@intelsat*.access. For Internet Service Providers establishing access to a backbone network point of presence.
- *@intelsat*.enterprise. To fulfill connectivity requirements of corporations to ISPs as well as to support Intranet and Extranet applications.
- *@intelsat*.multicast. For Intranet/Extranet point-to-multipoint applications (Web caching, UseNet newsgroups, digital/audio multicasting, real time database updates).

4.2 Initiatives in the Video and Broadcast Market

For years, INTELSAT provided the Video and Broadcast industry with services for television program contribution to studios and for program distribution to viewers. Services are available for short term and for long term use. They are being made more flexible and accessible: for instance, through the use of an Extranet, customers can book capacity for occasional use directly on-line.

INTELSAT will also start providing Direct-To-Home (DTH) service over Asia. It purchased a high power K-band satellite to be delivered in 1998. This satellite will provide direct television to viewers in India, China and other areas in the Asia-Pacific region.

4.3 Internal Reorganization

A vast internal re-engineering effort started over two years ago. Many business processes have been improved. The most visible part seen by customers is in the area of Sales and Marketing. The Sales functions are organized in a matrix structure, with regional focus and product focus. Product marketing has been increased in order to keep up with new customer needs.

In order to get closer to the market place, regional offices have been opened in Europe (London), in India (Bombay) and in Singapore. They provide an improved support and better communication between INTELSAT and its business partners.

An Internet Home Page available to the general public and an Intranet accessible to authorized customers have been put in place in order to make information more easily accessible.

4.4 Evaluation of the Formation of a Commercial Subsidiary

Parallel to the internal restructuring effort, a more radical change is under consideration. Over the last two years, the owners of INTELAST have been evaluating the possible need to spin-off a separate commercial entity which could operate as any other commercial company, not being bound by the rules of the present cooperative. The cooperative would remain in order to serve INTELSAT's core business (Global Voice and Data services). The commercial entity would focus on Video and Broadcast services.

The April 1997 Assembly of Parties (representing the governments participating in the INTELSAT organization) affirmed its intention to authorize the establishment of a commercial affiliate. It decided to establish a new group (Working Party) to study, in cooperation with the Board of Governors (representing the investors in the INTELSAT system), specific outstanding issues needing further development and/or resolution prior to the establishment of a commercial affiliate. This group must provide final restructuring recommendations in early 1998.

4.5 Longer Term Development

The definition of long term strategies and the vast effort in Research and Development help guarantee a healthy future for the organization. A non-exhaustive list includes:

- Evaluation of new satellite technologies (LEO, MEO, On Board Switching, Inter Satellite Links, antenna technologies, low cost terminals).
- Plans to offer increased services in the Ka and Ku frequency bands.
- Filling of new orbital locations and new frequency bands.
- Evaluation of partnerships and joint-ventures.

5. Conclusion

The many changes in the satellite market, such as the booming demand for traditional and new services, the availability of new technology and deregulation are redefining the industry. In its efforts to meet these changes, INTELSAT is evolving from a technology focused to a customer driven organization. While doing this it still keeps its long time recognized technical excellence. These changes make INTELSAT an even stronger partner in the telecommunications industry.

References

1. INTELSAT Home Page, *<http://www.intelsat.int>*

Report on Panel Discussion 3

Strategic Issues: Global Perspectives

Panel Discussion:

R. Doré

F. Dodu

G. Khozin

I. Pryke

Z. Vasilis

Concerning the major bottlenecks in international co-operation and a plan of action for dealing with them, **I. Pryke** considered that many fora and organisations are addressing this issue, but that no magic formula had yet been created. The co-operation will have to be tailored to each activity. People working in disaster management are not always fully aware of what remote sensing can do for them; remote sensing is definitely taken into account in these workshops.

R. Jakhu asked two questions to the panel: first, whether they could give a definition of international co-operation, and, secondly, how difficult it is to achieve international co-operation if the dominant player has the goal to dominate in the space sector. **F. Dodu** replied by saying that international co-operation might be difficult to achieve, but that a lot of examples can be given of successes in international co-operation, for example, INTELSAT. He also gave the example of Hispasat, launched by Spain. This could be seen as a national program but in fact it could create consortia between Spanish and Latin-American TV broadcasters, a form of international co-operation. **G. Khozin** agreed to give a definition of international co-operation. He defined it as pulling together efforts of participants under shared missions and concepts. He also added that this pulling together was dominated by a western mentality.

The last question, asked by **F. Wangusi**, an MSS student, concerned the utilisation of the International Space Station by non-partners, who have to be

accepted by all the partners in order to be able to use it. The reality, however, seems to be that the USA will never allow certain countries to use the station. Has it ever been considered that such extremes might occur? He also asked if developing nations are ever considered to contribute to the International Space Station. **I. Pryke** answered by explaining that all the partners have a certain amount of utilisation rights. The partner can then decide to make the station available to non-partners. Certain countries would have to be discussed by all the partners before they can be allowed to use the station. The station is to be used for peaceful purposes, but this means different things to different partners.

Session 4

Strategic Issues: Business Perspectives of Space Opportunities

Session Chair:

P. I. Yu, Associate Professor, Dept. of Industry & Management, Satellite Technology Research Center, KAIST, Korea

Featured Address

Privatization of Space Flight Operations

James C. Adamson, Chief Operating Officer, United Space Alliance, Houston, Texas 77058, USA

Abstract

The establishment of United Space Alliance (USA) as the single prime contractor for NASA's Space Shuttle operations is a significant step toward the privatization of America's human space flight activities. The Space Flight Operations Contract that NASA and USA signed in 1996 transfers responsibility for management and operations to the private sector, advancing the Space Shuttle program from an inherently governmental function toward a commercial enterprise. The contract does not specifically provide for the privatization of the Shuttle program, but it does place accountability under a single contractor. The next step is the transfer of total operational responsibility for the program to USA, a move that, from an industry perspective, would constitute privatization. The ability of industry to establish a commercial market for human space flight operations and to generate revenue from other non-NASA customers will be the determining factor in the program's progress beyond privatization toward commercialization. Reducing the cost of flying payloads aboard the Space Shuttle while ensuring safe reliable delivery will be key in attracting other agencies and new commercial customers in this market. Market share will naturally be limited to those orbits serviceable by the Shuttle, and the assembly of the International Space Station will place a significant demand on the manifest for the foreseeable future. Beyond these limitations, however, the Space Shuttle has considerable commercial capability on the "continuum" between a privatized government function and a truly commercial enterprise.

1. Privatizing Government Activities

In his "Determination and Findings" report to Congress dated November 7, 1995, NASA Administrator Daniel S. Goldin announced that the space agency would pursue a non-competitive contract with United Space Alliance (USA), then a Rockwell/Lockheed Martin joint venture, to be the single prime contractor for Space Shuttle operations (Reference 1). Following NASA's selection of USA, Rockwell's Space Operations Contract at the Johnson Space Center in Houston, Texas, and Lockheed Martin's Shuttle Processing Contract at the Kennedy Space Center (KSC) in Florida were linked to USA in April 1996, effectively establishing USA as the single prime contractor for Space Shuttle operations. Later Rockwell's logistics contract at KSC was added. The Space Flight Operations Contract (SFOC) consolidated the work content of the three major contracts under a single contract that became effective on October 1, 1996. The establishment of USA and the SFOC marks a distinct change in the management of America's human space flight programs and an initial step toward privatizing the nation's major space activities.

The term "privatization" typically refers to the transfer of a governmental function to the private sector for the management of day-to-day operations that the government performs for its own purposes or for the public. NASA defines privatization as the transfer to the private sector of responsibility for providing ongoing necessary services or functions currently provided by the government for itself or others. USA defines it as occurring when complete operational responsibility is transferred to the contractor.

Privatization, in general, can be implemented on three levels: outsourcing, corporatization, or divestiture. The government can "outsource" its needs for space flight products and services to private industry, a process that has already begun with USA. Or the government may create a private corporation similar in scope to AMTRAK and the U.S. Postal Service to perform specific functions. Or, under the third scenario ("divestiture"), the government transfers full responsibility and management control for operations to a private entity which competes commercially for domestic and international business.

Privatization has a distinct position on the "spectrum" of government oversight and control that ranges from inherently governmental functions, at one extreme to inherently commercial functions at the other; privatization is near the commercialization end of the spectrum. As government oversight decreases so contractor responsibility increases. The government can contract out in different ways that have differing degrees of responsibility transferred to the contractor. In the more controlled forms, such as level of effort cost plus fee contracts, government employees actually supervise the contractor and determine how products and services are provided. Under the Government Owned Contractor Operated (GOCO) scenario, the government specifies what is to be provided and the contractor determines how to provide those products and services.

Differences between points along the spectrum are not equivalent. The most significant difference lies between privatization and commercialization. This difference involves many factors, including the development of or existence of non-governmental markets for the same or similar products and services that the government currently purchases. If the market potential exists, the private sector will invest in developing such markets and in the capital assets to produce the products, and it will assume increased risk of loss. The important aspect to achieving this phase of the transition is the market potential and the reliability of the revenue sources required to offset investment risks.

Inherently governmental functions are usually characterized by a distinct public interest which demands that the government perform certain activities such as writing and passing laws, regulating commerce, maintaining a national military and providing long-term research and development for economic growth. The government also conducts certain activities that industry normally could not or would not conduct including investing in high-risk activities for which no market currently exists and no potential for one can be foreseen in the near term. An example would be NASA's current funding for space ventures such as the X-33 and other reusable launch vehicle programs, an endeavor that is too risky for industry to pursue on its own.

Changing market conditions and maturing government programs tend to shift project management needs across the spectrum. National and global markets change and expand over time as does industry's capability of managing programs that were previously in the government's purview. Government should not compete with its own industry for market share if the market exists commercially or if it can be created outside of the government. Government research and development programs may mature to the point where industry can manage them more efficiently and, at the same time, allow appropriate federal agencies increased resources to pursue new projects. The Space Shuttle is a good example of a former federal research and development project that has matured to the point of being fully operational and more efficiently managed by private industry. For this reason NASA decided to transfer Shuttle operations to a single prime contractor and remove itself from day-to-day management.

2. The Space Shuttle Program and the United Space Alliance

Economic factors may also drive the need to transfer programs across the spectrum from the federal sector to private industry. Whereas governmental organizations are motivated to spend their budgets, private enterprises have the incentive of making a profit. The performance-based SFOC shifts greater accountability for the management and success of the Space Shuttle program to USA, and it includes additional profit incentives to motivate the contractor to maintain safety of flight, meet the mission schedule and reduce costs. Under the terms of a performance-based contract such as the SFOC, the government buys deliverable and quantifiable products for a negotiated cost and leaves the determination of how to perform the job to the contractor. If the contractor can further reduce the cost without affecting safety or quality, the contractor may increase profits by sharing a portion of the savings with the government customer. This is the "shareline" feature of the contract.

Although the signing of the SFOC is a significant shift toward the privatization of America's major space activities, it does not specifically provide for the privatization of the Shuttle program. It does, however, place management accountability under a single contractor. The next step is the transfer of total operational responsibility for the Space Shuttle program to USA, a move that would constitute "privatization" from an industry perspective. Fig. 1 illustrates features pertaining to aerospace contracts that have progressed the space program from previous level of effort contracts to today's single prime contract and that will lead to privatization and conceivably commercialization.

Privatization - Space Flight Operations Contract

- SFOC is a significant step to privatization
- Next step is transfer of total operational responsibility to USA
- Final step is complete commercialization

			Privatization	
Factor	Level-of-Effort Contract	Single Prime	Total Operation/ Responsibility	Complete Commercialization
Top level Management	Government	Government/ Contractor	Contractor	Contractor
Day-To-Day Operating	Government	Government	Contractor	Contractor
Control of Manifest	Government	Government	Government/ Contractor	Contractor
Asset Ownership	Government	Government	Government	Contractor
Financial Liability	Government	Government	Government	Contractor

Figure 1. Transition of space flight operations from single prime to privatization and commercialization.

Fig. 1 illustrates progress toward privatization and commercialization of America's human space flight operations. USA, as the single prime, has

established a senior management team to oversee day-to-day Space Shuttle operations. USA is now responsible for most of the processes and tasks that NASA previously managed. Most safety and mission assurance tasks, program integration, flight and ground operations, and integrated logistics support for Shuttle systems have been transferred to USA.

As USA demonstrates its ability to manage these tasks, additional Space Shuttle subcontracts will be transferred under integrated SFOC management. NASA and USA have begun to plan Phase II of the SFOC which will bring additional work including subcontracts for the Space Shuttle external tank, main engines, reusable solid rocket motors and the solid rocket boosters. These contracts will be placed under USA management by the end of FY99.

As the matrix of Fig. 1 shows, control of manifest and launch scheduling marks the final stage of privatization and the initial step toward achieving some degree of commercialization. At this privatization stage, the contractor would assume total operational responsibility for the program.

Commercialization may be defined as occurring when ownership, responsibility, liability and control are transferred to private industry. Industry then competes for domestic and international business in addition to maintaining previous customers within government. Achieving commercialization will depend upon two primary factors: the outcome of investment decisions that weigh return versus risk considerations and the contractor's ability to develop a commercial market for space operations. Developing a commercial market will depend upon the contractor's ability to commit to flying commercial payloads.

Many financial and legal constraints must be resolved to advance space operations from the privatization stage to commercialization. These issues include transferring ownership of spacecraft and other assets from the government to industry, accounting for all assets and establishing a commercial market to generate additional sales. Market-related questions will call for industry to measure how much it is willing to put at risk versus how much return is possible for assuming additional liabilities. The ability of industry to establish a market for human space flight operations and to generate revenue from customers other than NASA will be the determining factor in progressing the program beyond privatization to commercialization.

Establishing a non-NASA market for Space Shuttle operations will be difficult. Reducing the cost of flying payloads aboard the Space Shuttle to add

Department of Defense and new commercial customers will be critical to achieving this objective. Currently the orbits serviceable by the Space Shuttle launched from KSC are limited to inclinations less than 60 degrees. Higher latitude and polar orbits will not be reachable without upgrades like liquid fly-back boosters or the use of other launch sites. In addition, upper stage configurations required to service higher altitude MEO and GEO orbits with Shuttle will take time to find their way into the pipeline. Limitations like these, and the fact that assembly of the International Space Station will occupy a large part of the manifest, will prevent Shuttle from competing for a large share of the commercial market in the near term. From a launch capacity and pricing standpoint, however, Shuttle has the potential to become very competitive and has a bright future.

3. Discussion

In summary, many of the questions related to commercializing human space flight operations remain unanswered. In the mean time the task at hand for USA is to move the role of the contractor along the spectrum toward privatization, with the transfer of functional ownership being the next objective. Approximately 70% of the tasks and responsibilities associated with managing the Space Shuttle program have been transferred to USA to date, with transition of the ownership program functions being the next milestone. Beyond that, program requirements' control, launch authority, and manifest control will have to be transferred before privatization can be complete.

These are not easy transitions to make. They involve fundamental changes in the relationships between the contractor and its civil service counterparts. Government workers must relinquish responsibility and accountability, and the contractor must be prepared to accept these. Many civil servants do not want this to happen and resist the change. Others support it and try to expedite the transition. Fears of job security, unsafe practices, and loss of critical skills are routine complaints. Senior management is constantly challenged to ascertain real safety concerns from ungrounded fears and must keep constant pressure on the change process.

Looking further into the future, USA is conducting a study to define the addressable commercial market for human space flight operations, considering many factors including excess capacity on NASA flights, orbital parameters versus commercial market needs and incremental costs of new flights. Due to the previously discussed orbital limitations and with the assembly of the International Space Station, capacity to accept non-NASA customers will

initially be limited to just a few flights per year. Further developments like liquid fly-back boosters, orbital transfer vehicles and Shuttle upgrades could change that. However, it seems that the Space Shuttle program will be in the middle of the spectrum between a privatized governmental function and a truly commercial enterprise.

Biographical Note

Based in Houston, United Space Alliance (USA) is a Boeing/Lockheed Martin joint venture established to conduct the Space Flight Operations Contract (SFOC) for NASA. Jim Adamson, formerly a NASA astronaut and an executive with Lockheed Martin, serves as USA's chief operating officer.

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Market Strategy and Ethics

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Abstract

We are in the era of a global economy, unaffected by national boundaries, witnessing the interaction of various cooperative and competing forces and a new balance between public interest and private enterprise. There is a general movement towards privatization. New markets can be opened almost everywhere; the possibilities in the space field are immense -spaceports, launchers, telecommunications, remote sensing, data exchange, GPS, novel applications, etc. With globalization, interaction and connectivity, we must ensure that dangerous short-sighted interests do not prevail; any mistake would immediately affect the whole system. Opening new space markets, the space community should be sure that actual needs are addressed without creating a disturbance within the overall environment. Market strategy uses promotion and advertisement, which means persuasion. Quality must be pursued and, globally, the costs of a single private achievement must not exceed the improvement (for example, job creation in one field should not reduce the overall opportunities for the local community).

We propose that ISU, which is already a neutral forum for open discussion, analyses these issues, rather than leaving them to the policy makers; assessments within the field are more effective. Many advantageous enterprises can be driven forward without harming the overall environment, but some are only locally profitable. An objective approach is essential to respect global equilibrium; it is senseless to speak of sustainable development without it. Advertisement and market strategy can be dangerous because in competition (which is all but global) the advantage is pursued individually. Some limits to competition should be set, if the world is to be a global garden rather than a boundless jungle.

1. Introduction

This is a "critical" paper, a philosophical analysis of the new historical, political and economic situation which permits the opening of new space markets. This analysis is conducted paying special attention to drawbacks, in an attempt to counterbalance their impacts.

Philosophy is entwined with human history and is one of its driving forces. It is neither useless nor redundant, because philosophy is a holistic in-depth reflection on experience, data and their interpretation. Critical analysis offers us the possibility to think over our models and tools of knowledge; a cautious approach is useful when dealing with uncertainty. This is especially the case for phenomena with too many variables which are difficult to investigate and fully understand, like globalization.

A philosophical analysis is useful even if its results are provisional; it shares this characteristic with scientific research. In-depth studies take time and do not have practical applications in the short term. This is also true for

"big science", which is not so advantageous for profit at the outset; however, it can later offer interesting spin-offs to market forces and private enterprises.

This paper attempts to outline the main characteristics of globalization and to identify its weak points in order to overcome them with necessary, adequate precautions. Its aim is to raise questions on doubtful aspects of our promising present situation, and to bring them to the attention of the space community.

2. Characteristics of Market Forces

Though market economy implies competition and rapid decision-making, freedom and creativity in enterprise, in a global context, on a world-wide scale, we need reliable objective assessments on actual needs, so as to set some necessary priorities for long term planning. Many urgent problems are not economically rewarding in the short term, but need to be quickly addressed. Their solution cannot be postponed; otherwise humanity and the environment will be harmed (e.g. ozone depletion, global warming, space debris, energy, resource exploitation, food and security, disaster warning, overpopulation, etc.).

From the perspective of the policy makers, the crucial question is: since the private sector is expanding, and neo-liberalism winning worldwide, how do we attract it towards problems of public utility and convince enterprises of the opportunity (and convenience) of addressing seriously such "non-revenue" issues and participating in large scale projects? Obviously this requires cooperation with the public sector, and an international and interdisciplinary approach. Since large scale projects require coordination and political and economic agreements, as well as a long duration, which means economic stability, actual improvements may come only with a gradual decrease of competition or, better, of its ferocity, hopefully coming as a natural evolution of a market-oriented world. This means that improvements will come if Ethics are taken into account.

Thus, market economy is what we have today; we are at this point in the dialectics of history. It is not the intention of this paper to demonstrate how the new trend, though winning on the planet, is not fully appreciated by everybody, even if this fact should be remembered because it can provide useful insights into its drawbacks. Adopting the opponent's perspective is an occasion to perceive weak spots. Also globalization, as it is intended today, should not be seen as a final state of maximum equilibrium and peace, and as the ultimate

goal of history, because socio-political forces, as well as spiritual ones, are in continuous change and evolution in reciprocal relationship and do not compose a static order, which is contrary to life. Our objective is to portray the present situation, which is happening now, and show that there is an actual need for in-depth studies on many critical issues.

Can the enormous importance given to the Market economy limit Ethics? Its principles, taken to the extreme, may consider ethical issues to be unimportant and hence neglected.

Market strategy, which implies advertisement, promotion, creating new needs, rapid decision-making and resource exploitation, is essential for profitable business. Profit is pursued individually by different parties in free competition in the market place, which today is global. We shall point out that competition alone is not sufficient to produce excellence, at least when human, cultural phenomena are involved. As also in biology, competition is not the only factor driving evolution, especially in extraordinary phases of rapid transformation of the encompassing environment.

3. The Global View

The global economy, with its special features, is a natural consequence of a few facts. We list them.

- First, it is the result of an old idea, which is also of a philosophical nature. It is the natural development of the first liberal theories in economics of the 19th century (Stuart Mill, Ricardo, Bentham, etc.) and was envisaged from the start as a precise political plan which included free trade, privatization and deregulation. It is based on the optimistic assumption that, pursuing private advantage, individuals are always creating better standards for society as a whole, that very few limitations are to be set by States, and that all revenue activities should be left to creative enterprises.
- Globalization is a consequence of the historical victory of Capitalism over Socialism, and its extreme, Communism; this could be fully established at the end of the Cold War. Its roots are in the Bretton Woods Conference of 1944, and prior events, the creation of the World Bank and of the International Monetary Fund.
- Though many believe history is cyclical, the present situation brings evidence to the theory of linear evolution, of progress towards total novelty. In fact, this contemporary phase is quite peculiar in that it is the

first time that a single theory rules over the whole planet. Throughout history, and especially in the 20th century, other economic and ideological models have competed for universal diffusion; some of their elements have been in a way incorporated into what we now call globalization.

- Anthropology states that cultural elements which belong to a specific culture are not visible from within because they seem obvious to those who share them, and that possible mistakes are revealed subsequently by neighbouring cultures. So there is a large risk of unawareness today that, regardless of differences, many important cultural factors are the same everywhere.
- Globalization can also be seen as the obvious result of technological innovation. From a material point of view the contemporary world is held together by Internet, and other networks, as well as by the means of rapid transportation and all space-based solutions such as satellite telecommunications, TV broadcasting, GPS, Earth observation systems and remote sensing. Cybernetics and Hi-Technology duplicate and expand the interactive nature of reality.
- From a scientific standpoint, globalization in economics and politics reflects the understanding of the unity of our planet, the fact of sharing one biosphere and one environment with other terrestrial creatures: humans, animals, plants, bacteria, etc., a cosmic dwelling where all processes are interdependent and related. This dynamic, synergetic equilibrium is one made of change, movement, cooperation, transformation. And competition. So the global economy aims to mirror ecology and its strategies. Everything is interrelated and part of the articulate speech of existence. This is true within the limits of the Earth, of the solar system, the galaxy and the Universe.

4. Everything is Possible

Today there is increased understanding of the artifical, arbitrary nature of political boundaries, a major respect for human differences and more freedom. But the hidden danger of the new situation is the lack of clear international regulations.

Everything seems possible in this era: a magic composition of processes, the marriage of science and religion, experiencing together physical and spiritual joys. Apparently all is out there for everybody to reach. Total freedom is granted as to what should be pursued, thought and believed. This picture is rather utopian, because the whole is too much for each single part to grasp

entirely, nor can it choose adequately without knowledge, only on the basis of appetites. And these are the targets of production, they are the demand, interpreted, satisfied and anticipated with market strategy and persuasion. The striving for objective knowledge cannot welcome the seduction of advertisement, not without a contemporary increase in critical thinking. This double reinforcement is difficult to achieve.

Apart from being appealing, at least to a consistent share of the market, different products can be either useful, or attractive, but useless, or sometimes even harmful, to consumers and to society as a whole, trapped in a large luxurious shopping mall which it hardly has the time to visit. And all these products are advertised and promoted. Consumers, once called savers, at least in Europe, therefore become increasingly passive even in formulating their demands, and their life becomes empty and shallow, deprived of judgement and of imagination. There is a lot of redundancy and an excess of goods, services and a complete lack of safety out there. Are we sure that this trend should be further enhanced? Don't we need, on the contrary, some wise limitations so that it may be counterbalanced?

A strong image is not necessarily the sign of actual strength. A battle conducted on symbolic ground, which utilizes promotion and sophisticated, expensive market techniques is not totally honest to consumers and will not always lead to the victory of the best party. And if we still believe that competition is a sufficient evaluation criterion, how do we assure fair competition and equal opportunities for small enterprises, versus giant industries?

If we assume that victory in itself is a warranty of merit, aren't we also unconsciously saying that wars are necessary and abuse, even crime, justified and accepted as natural?

In the global arena, instead of leading to major self-control and autoanalysis, the absence of a commonly accepted moral authority has been considered by many as an authorization, a pass for all ambitions. But it is in the interest of the international community to prevent abuses. And this is why we are addressing these issues today.

For example, it is acceptable to move production to where labour is cheaper as long as the wages are locally fair and allow good common standards of living. But it is debatable if it is the case to exploit a doubtful situation, taking advantage of the lack of regulations, or of local political difficulties to build

economic empires. Human rights must be always respected, and adequate protection must be granted to workers, their future and the environment. This is an ethical necessity. Industry offers employment, and training, but it follows profit, and hence its interests may shift very quickly.

It is especially important at the end of the welfare state to address and answer these questions. There is a risk that, while social assistance will decrease, poverty will increase. On the other hand money might be more evenly distributed from a geographical point of view but, with growing overpopulation and continuous technological automatization, the world's population risks to be seriously impoverished. Consider, for example, health care and medicine: who will pay the bill for the future medicines made in space? To whose advantage is such scientific research being pursued?

Thinking of pharmaceutical industries moving into space, it is interesting to ask: who will work there? Cloned individuals favourably adapted to that hostile environment? It is easy to imagine tight interactions between powerful industries such as space, bioengineering and cybernetics. What is the world which we are building in our ecstatic appreciation of speed and apparent technological dominion? Can we avoid ecological problems? Any one of the factors listed in this paper, that gets out of control, can cause disaster. Are volunteers to take care of social assistance? Does this mean that being good and civilized becomes optional? What solutions are we going to propose? What are politics going to mean in the 21st century? And nations? Who will be in control of weapons and give security to our planet?

All these problems are specially relevant for space; they can only be tackled jointly by the public and private sectors and on an international level. Space has always been the symbol of unity - it gives us the vision of the oneness of our planet. Its costly projects have always required joint efforts and cooperation. Space is a very complex industry, related to others; any influence starting from here can reach all. If we believe that ethical considerations are worth a second thought, let us start from here.

We cannot leave these issues without consideration. The global village aims for synergy, and needs to give itself some reference points. On the planet, the speed at which things are moving is not favourable for a peaceful, harmonious evolution and for the settling of problems and differences but, on the contrary, to the growth of misunderstandings. Tolerance is today present in the forms of mutual isolation and egoism. Global Villagers are maybe united on

the World Wide Web, but distant from neighbours across the street. Are we competing against our neighbour? What are human relations to mean?

To point out major difficulties is not always considered to be politically correct, but what is politically correct? To use diplomatic skills to flirt with different partners proposing an attractive provisional image of oneself, or to make honest less astounding assessments? The present offers great opportunities but grants little time for in-depth analysis, because we live in an era of maximum speed and inflation. Also slowness is not compatible with money making and the speed of enterprises, or with the optimization of private interests. We promote useless goods, waste resources and create new needs. This happens to save industry, under the pressure of technology push, and it prevents unemployment, but it leads to a continuously growing vicious circle, which in time will devour us.

5. Conclusion

Some limits to competition should be set, if the world is to be a global garden rather than a boundless jungle. The world was also global before; there have always been communications and contacts within nations, cultures, markets, religions and ideas. The difference today is the increasing speed of interactive phenomena, and the fact that they are geographically global; innumerable contacts occur simultaneously everywhere.

We not only need an increased ethical awareness, but also to set explicit agreements on what we consider admissible from an ethical perspective, standing out and declaring what we shall not tolerate from any financial partner. Ethics is nothing more than a search for objectivity and respect towards the principles that emerge from understanding.

Potential of Hands-On Venture Capital for Space-Related Growth Companies

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Abstract

Venture capital with its capabilities is an appropriate instrument towards commercialization. While billions of dollars of equity are invested in tens of thousands of young and mostly technology-oriented companies each year, the space community is still struggling with fairly unsuccessful commercialization efforts. Two major reasons have caused this dilemma: the lack of interaction and communication with the business world, and missing skills among the players in the space community to push the desired development to realize a reasonable number of fully commercial activities. Being in the international venture capital business for nearly twenty years, and being familiar with the space sector, GENES has, after intensive analyses, decided to develop in co-operation with the relevant players space-related venture capital to support a real commercialization process in space. However, the experience so far has shown that the space community must first do the necessary homework as well as make visibile commitments. The requirements for the involvement of venture capital in space are given, and two pilot programs are suggested. The first is a focused educational approach to generate and ensure the ability to understand and communicate business, and the second is the setting-up of a specially tailored international venture capital fund for space. The overall goal of such activities is to relieve the budgets in the long term, and to create jobs by generating sustainable businesses which will profit space, the investors and the economy.

1. The Secrets of Venture Capital

The scientific and technological potential of the space sector is obviously tremendous and its skilled manpower base is unique. Global downsizing in the 1990's and shrinking space budgets worldwide have brought up an intensified discussion on space commercialization. Since the space industry as well as R&D bodies suffer from budget cuts or fewer governmental and agency contracts, the need to enter new markets and to interact more with private sector industries are now priorities. The entrepreneurs and institutions in businesses exploiting the technology derivatives of space endeavours know that space is one of the most exciting commercial growth sectors today. Here there are opportunities for venture capital (VC) and the managers of space activities.

1.1 What Is Venture Capital And How Does It Work?

VC is "capital plus", "involved capital" or "smart capital". That means equity for technology-oriented growth companies plus active support or "value adding". Such pro-active finance is typically provided by VC funds that build a portfolio of companies. The money can come from sources like institutional

investors (such as pension funds, insurance companies or banks, etc.), industrial investors or private individuals. The venture funds take equity positions in the companies which are often realized in syndicates with other venture capitalists. The objective is a real partnership which enables the entrepreneurs to grow their companies and to generate superior returns for the investors. The higher the risks involved, the higher the chances for the investors. The intermediaries are the fund managers adding value to the companies by active coaching and by providing expertise, connectivity and everything necessary to reach the common goal. An advantage of this is that the fund managers have a natural interest in being successful, since they usually participate in the fund's performance. When the time has come to realize the investments, there are typically three ways of exiting. These are the preferred floatation (initial public offering), trade sale - to another company - or buy-back by the company or the management. VC creates a win-win structure.

1.2 The World's Equity Finance Business

Equity plays a key role for the successful development of young technology-oriented companies, because of the risks involved, and uncertainties due to external influences such as market dynamics, suppliers, capital costs, etc.. During the last century wealthy people and a few private banks acknowledged this by starting first equity finance activities. Earlier this century groups such as the Rockefeller and the Whitney families started institutionalized efforts when they set up their own VC firms and funds. Others followed until, in the 1950's, the US Small Business Administration through the SBIC-Program started an avalanche of VC firms. This led to such developments as Silicon Valley, south of San Francisco, or Route 128 around Boston; there thousands of innovative companies were founded and venture-backed, and some still dominate the world market. Today, it is primarily VC funds and "business angels" that drive this business on the young companies side. Especially over the last decades, this has become an industry itself. The important players are:

- bank-related funds
- industry-related funds
- independent venture capital funds
- "business angels"

The VC business has developed fast since the early 1980's, and has spread all over the world. The US leads this industry, but evolving activities can be observed in Europe and Asia, supported by a global tendency that more money has become available for such alternative investments. This process was

definitely encouraged by outstanding successes, which were achieved (average internal rates of return (IRRs) of VC-funds in the US in 1995 of 35%, and close to 200 public offerings of venture-backed companies). Today there are estimated to be about 2,750 private equity players in business who raised in 1995 about US$ 45 billion. (See Table 1).

Where	How many	Capital raised in 1995
USA	1,400	US$ 28.4 bill.
Europe	600	US$ 5.5 bill.
Asia	550	US$ 6.7 bill.
elsewhere	200	US$ 4.4 bill.
Total	**2,750**	**US$ 45.0 bill.**

Table 1. Number of private equity players (from Granville Private Equity Funds)

1.3 The Economic Impact Of Venture Capital in Europe

European VC funds in 1995 have invested over US $ 6.7 billion in more than 25,000 companies; 46% of the money invested went into buy-outs and 41% into expansions, while only 6% was placed in start-ups and as seed capital. The stage distribution by percentage of number of investments was 53% for expansion, 21% for buy-outs, and 19% (4,750 companies) for start-ups and seed funds.

A survey of the impact of VC on investee companies, and on the European economy, was recently conducted by the European Venture Capital Association (EVCA) in co-operation with Coopers & Lybrand Corporate Finance. The following results derived from a representative selection of 2,200 companies in 12 European countries were compared with the performances (job creation, investment, exports, other economic factors) of the top 500 European companies:

The characteristics and advantages of venture-backed companies are as follows:

- "They are young and medium-sized": nearly half of the survey companies were founded in the 1990s, and 74% are small and medium-sized with an average turnover of US$ 45 millon. Approximately 40% are planning a listing (going public) on the national stock exchange markets.
- **Venture-backed companies stimulate the economy:**
- "They are fast-growing": despite difficult economic conditions, over the period 1991-1995 they experienced exceptional growth rates, outperforming those of the top 500 European companies. On average, sales

revenue rose by 35% annually, twice as fast as for the top European companies.

- "They create jobs": staff numbers increased by an average of 15% per year over the same period, but only by 2% for the top European companies.
- "They invest heavily": investment in plant, property and capital equipment grew by an average of 25% annually. In 1995, R & D expenditure represented, on average, 8.6% of total sales compared with 1.3% for the top European companies.
- "They develop internationally": on average, their exports rose by 30% per year, strengthening international competitiveness.
- **VC investors are active partners, providing both financial and non-financial support:**
- "They provide equity to support fast growth."
- "They provide guidance and expertise": advice on financial and strategic matters, acting as a sounding board for ideas, assisting by providing market information, by recruiting management, helping to develop market strategies, etc..
- "Their contribution is highly regarded": over 80% of the investee companies' managers believed their company either would not have existed, or would have grown less rapidly than if it did, without VC.

The VC business in Europe is still not comparable to that in the US but, related to the federal structure of Europe, the recently and still slowly developing exit channels (liquid stock exchange markets) and hesitating investment culture, with average IRRs of 15% annually (mainly caused by successes in management buy-outs), show that a professional industry is in place. Globally, there are substantial, professionally managed VC funds, which have not yet been approached by the space community.

1.4 What Makes Venture Capital Tick?

The secret of the success of VC financing can be derived from the decision criteria used in the investment process. Venture capitalists focus their investment decisions on the following core points:

- Management
- Market
- Product
- Return.

Management. The prime criterion of companies looking for equity finance is the management team. Business success is sensed and created by individuals with an extreme success and profit orientation, and an excellent background in the relevant markets. They typically - at least in high-tech areas - come in teams with complementary experiences and skills. Therefore, these teams do not solely consist of scientists and engineers, but also (and often primarily) include people from the industry with backgrounds in:

- general management
- marketing and sales
- controlling and finance.

For technology transfer projects in space this means: pick team members who are among the best of the industry - from the target industry - and use them as the core of the entrepreneurial team. They must be seen to complement the scientific and engineering heads of the space development organisation (inventor team). Such a team composition will ensure business success through their market- and profit-orientation, and by using proven instruments for market entry and penetration on the basis of a sound financial structure. Venture capitalists have the ability to sense the success-potential of entrepreneurial teams. They are often also involved in building such teams.

Market. VC investments are not made to realize ongoing returns from dividends or interest payments. They solely aim at capital gains. Capital gains are achieved by buying stocks of companies low and selling them high, within a timeframe of typically 3 to 5 years. This goal can only be achieved with growing companies:

- growing in size
- growing in profits and/or
- growing in value.

Such growth can typically be realized in emerging and growing markets or in markets that go through a period of rapid restructuring. These are the target markets for VC investments. Space-related projects should therefore aim at markets with convincing growth or restructuring potential, and neglect stable industries and niche markets.

Product. VC investments are typically made in products or services with unique features. Therefore investee companies need to be on the leading edge of technological development on a global scale. The reasoning is again based on

the capital gains-orientation of VC investing; only pioneering situations offer the kind of potential which is necessary for rapid growth and expansion of sales and profit. Space-related projects score best on this criterion. Space projects are by their nature at the forefront of technical development, and more and more join similar ambitions from space organisations in other parts of the world. This is the breeding ground for technical and - hopefully - market breakthroughs.

Return. VC is a very "capitalistic" way of financing, since it is driven by the profit motive. Managers of VC funds raise the capital primarily from institutions (banks, pension funds, insurance companies, endowments, etc.) and industrial sources. These fund investors conduct an asset allocation process in order to direct their money to the best investment classes. VC belongs to the asset class "alternative investments", which is characterized by high risk, but also high potential for returns. Typical returns per annum realized in VC are 15 to 30%. These returns differ by country, fund vintage and stage of development of the target companies. In making investment decisions the venture capitalist has to pick those companies which offer appropriate return potential. In the case of space-related high-tech projects, the aim would be to realize, on an annual basis, 30 to 40% IRR. This high number is caused by the high risk involved, because it has to compensate those portfolio companies which fail or which are underperforming.

1.5 Venture Capital vs. Bank Financing

Equity vs. debt. Banks of the "universal bank" type typically supply companies with debt capital and in return ask for:

- interest payments
- guarantees and
- good standing.

Early stage and high-tech companies normally cannot meet these criteria, because they are often still in the product development process and lack the ability to pay interest or to offer guarantees or other collateral. This is why innovation loans or similar programs for many young, high-tech companies are not an appropriate way of financing. VC is based on the partnership idea: the venture capitalist becomes a shareholder of the company, invests by buying stock and follows parallel interests with the entrepreneurs (equity-oriented). Interest payments and guarantees are not part of the contractual agreements. In

contrast, the partners to such agreements base the capital infusion on the business plan and a joint understanding of the strategy of the company.

Value adding. VC is often defined as a value adding exercise. The senior partners of the VC management company are typically experienced businessmen, who have been involved in young, fast-growing companies before. They often focus their investment criteria on certain industries or technical areas in which they have developed special expertise and a personal network. To each senior partner of a VC group, 5 to 6 investee companies are usually assigned for constant monitoring. This limited number ensures that the senior partner can spend sufficient time with the investee companies in order to add those personal resources (experience, early stage know-how, connectivity, etc.) which young companies generally do not possess.

Motivation of senior partners. The senior partners of a VC management group are highly motivated to aid the development of their portfolio companies, because they have the chance to make a lot of money for themselves along with the members of the entrepreneurial team. It is usual in the VC business to offer a "carried interest" to the senior partners. This is in most cases a 20% participation in realized capital gains, which are distributed among the partners as soon as investors have received their money (often plus a certain additional amount, or "hurdle") back. This type of success-based compensation ensures the ongoing personal interest of the senior partner in charge in the positive development of the investee company.

Exiting. In typically three to five years, the venture capitalist wishes to exit from the investment. Up to this point the investment is illiquid, that is, not creating liquidity for the venture capital fund. The profit for investors is made at the end of the stockholding period by selling the stock. Three different routes are available as shown in Table 2.

Exit Route	Profit Potential
IPO (Initial Public Offering)	high
Trade sale	good
Sale to company/ management team	low

Table 2. Profit potential of exit routes

Because of the high profit potential in using the stock market for an IPO the availability of a public market for young, growing companies (like NASDAQ) is essential. Latest developments in Europe (EASDAQ, AIM and NM-markets) show the positive trend in what used to be non-existent.

Optimal financing structures. The modern approach to business finance links the type of financing to the development stage of the company. It is obvious from the above mentioned criteria that VC financing is a more appropriate means of financing young high-tech companies because of:

- the parallel interest of the investors and the entrepreneurs
- the illiquid nature of VC during the phase of rapid growth
- the "money plus" or value adding strategy of an involved VC investor
- the high motivation of the senior partners of the venture management group
- the high profit potential for the VC investor and the management team within the medium term.

While debt financing often hinders and strangles young growing companies, VC is tuned to the needs of this type of business. This applies to most space-related young companies.

2. The Space Sector from a Venture Capital Investor's Perspective

Some insights of the VC business and other players in the finance industry are presented regarding opportunities for commercial space ventures. Spin-offs in the past have primarily been "fall-outs". Successful commercial applications such as the miniaturization of computer chips, structural analysis software, medical technology, grooved roads, etc., are almost forgotten, but have generated multiple paybacks out of those. However, the space community overall has not made significant profits. That requires a special kind of people-driven selling of space-related know-how, technologies and products, and that is still an opportunity for the space community.

A sound technological and scientific base, an excellent infrastructure, laboratories, etc., and a skilled manpower base are required. The international, interdisciplinary, and intercultural character of space, a willingness to commercialize (which has become policy), a good image (know-how) and a positive flair, as well as enormous investment and business opportunities are assets of the space sector. However, in the past, space was driven by single sourcing from public budgets and not by market orientation or profits. Therefore, the lack of adequate management skills, obsolete financial expertise, the missing entrepreneurial spirit, and bureaucratic processes ("red tape") caused space people to be regarded by business people as egocentric and self sufficient. The ability of the space community to turn ideas into concepts and business plans is weak; the important transition from R & D into applications is too

slow. Too seldom are new companies founded as separate entities, and too few, significant good examples yet exist.

2.1 Examples

Despite tremendous business opportunities (at least theoretically), only a few venture-backed space activities are visible to date. The most advanced approach is the US$ 50 mill. SpaceVest Fund, launched in 1995, and exclusively financing space-related companies. To date the portfolio consists of 10 companies and is developing well. Spacehab (founded in 1984) benefited from Polyventures' venture capital investment in 1987 and became profitable in 1994 (1995 profit: US$ 15.8 mill.) before going public in December 1995. GENES involved space know-how from a hypersonic program (in structural mechanics) in one of its portfolio companies (automotive supplier for Volkswagen and Audi) to develop prototypes of fully composite-substituted cardan shafts and driving axles.

3. How to Involve Venture Capital in Space

To meet the expectations of venture capitalists requires preparations by the space community and the teams involved. At first, the communication gap between space and non-space industries and the financial community has to be overcome, and space has to be promoted in those areas adequately. In return, the "outside-world's" language and culture has to be adopted by the space community. This means that the business creation process, finance, and the development of professional business plans have to be understood. Also a change in culture, such as risk readiness, entrepreneurial spirit and visible commitments have to be developed; this requires the involvement of expertise and practical experience. Two major activities to be realized in parallel should be considered as pilot projects to accelerate the commercialization process in space.

3.1 Education Programs to Change the Culture, and Promote Necessary Attitudes and Skills

Various activities such as "entrepreneurship institutes", workshops and seminars on business creation, finance, etc., case studies, benchmarking and "venture clinics" could significantly contribute to fostering commercialization and competitiveness in space activities.

3.2 An International Venture Capital Fund for Space

Because of the nature of the space sector still being incompatible with common structures in non-space businesses and the financial community, an insightful and specially tailored capital facility for space activities should be developed. This would preferably be an international VC fund aiming at meeting commercial innovations, competitiveness and technology transfer. Such a fund could provide smart equity to stimulate commercial space activities by building sustainable businesses. Its investment focus should target space core activities, space spin-offs (technology transfer and other terrestrial applications) and combine a "fund-of-funds" function. Geographically, the spacefaring nations and selected others worldwide could be considered. With a minimum target size of US$ 100 mill. and fed by the space community (as lead investor) and institutional and industrial investors, subsidies, and supporting programs, 15 to 20 investments (early-stage, expansion, medium and large business opportunities, MBOs, LBOs) could be made in 3 years (liquidation after 10 years). A basic requirement is to put an experienced fund management with a background in space and excellent connectivity in charge of this.

Such a fund would have several advantages compensating for the current lack of funds for space. First, adequate finance could be provided, accompanied by value adding and coaching. Secondly, core activities as well as transfer opportunities could be financed. The size of deals can reach reasonable sizes by involving investment syndicates or by leveraging. Thirdly, the fund-of-funds approach allows cross-border and cross-industry relationships to provide connectivity, new markets and insights on alternative methods and procedures. Another important effect would be the transition within the space community towards competitiveness in new markets; budgets could be relieved, too.

4. Conclusion

Specialized VC can help to identify, acquire, fund, develop and monitor selected high-technology enterprises and fully exploit their commercial potential in building highly profitable, financially-sustainable businesses with international growth. Encouraged by an excellent transnational network in the space sector, in the financial community, in industry as well as in R & D and many years of experiences in generating, financing, coaching and monitoring young companies, GENES is eager to further develop activities for space commercialization in co-operation with the relevant players.

Report on Panel Discussion 4

Strategic Issues: Business Perspectives of Space Opportunities

The aim of the private sector is to seek opportunities regarding the overall value that can be gained through two processes: increasing the revenue, or decreasing the cost. In achieving a new space market, business must not only consider all aspects of the activities on a long term basis, but also account for the risks that may be inherent.

Today, market forces should drive space activities; however, the general market rules are not satisfied in the space market as there is a shortfall in both demand and supply. Therefore, new space markets are needed to create opportunities within the space industry.

There are four obstacles to new space business:

1. By their very nature, space activities are long term and costly; industry prefers to focus on short term benefits.

2. Governmental control of space activities means that accountability, risks and competition are not major factors. This is needed at the beginning of a space program; later, various activities may be contracted out, privatised and then commercialised. The new role of NASA and other governmental organisations is to lead the way and create the technologies needed for new space activities. The technology is then handed over to industry.

3. A critical factor to be taken into account is the risk related to space activities. Space is a sophisticated, expensive high technology market; the associated risk is high and can occur in any phase of the process (during the pre-launch phase, during the launch, and in orbit). Therefore, it is necessary to have a clear approach through the identification, evaluation and management of risks, which should be minimised as far as possible.

4. The final barrier to space business is the lack of financial and management skills of space businessmen. Obsolete financial expertise and lack of entrepreneurial spirit explain why some do not address lucrative business activities in space. Venture capital activities can lead to a win-win structure,

or partnership, where high risks are taken; these represent a huge potential for space business opportunities.

In conclusion, space opportunities for business will be obtained through the commercialisation of space activities, the management of the risks associated with these activities, the education - and the promotion of necessary attitudes to change the culture - of the space actors. Nevertheless, with this privatisation and this globalisation, some limits to competition should be set, in order to respect the equilibrium of the global environment.

Keynote Address

Wall Street: The New Launching Site for Space Projects

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1. Introduction

Looking back, it is remarkable how far the space business has progressed in the forty years since the launch of Sputnik in October 1957. Earth's first artificial satellite was just 58 cm in diameter and weighed 83.6 kg. Satellites have evolved and matured since that modest start. Today's satellites, some weighing many tonnes, fulfill a variety of missions: communications, remote sensing and mapping, DTH TV, real-time intelligence gathering, and research. Here I include the Hubble Telescope, the Compton Gamma Ray Observatory and others, all of which are designed to unlock the secrets of the Universe.

Space too has changed. Once the exclusive domain of governments and the military, we have seen in recent years a growing private sector involvement in space. Space has become increasingly commercial in nature. I would like to focus on this aspect and the growing need for a new type of engineer to join the teams that have traditionally designed, built, launched and operated satellites. I am talking about a financial satellite engineer, a specialist who can help raise the immense sums of money needed to put large commercial satellite systems into orbit. This is a person who does not know or care about engineering parameters like wet launch mass, orbital altitude, inclination or precession unless they affect the financibility of a particular project. Such a person will have an impact on system technology, for engineering decisions must be traded off against financial consequences; as a result, we are all going to learn the lexicon of a new high-priesthood, with terms like first equity tranche, high-yield debt, leverage and initial public offering.

2. Financing New Space Systems

Commercial space is a capital-intensive place. It always has been, but I suppose that we tended to lose sight of that fact when governments and government agencies were paying the bills, and construction contracts were often of a cost-plus nature. The satellite business is also characterized by having high initial fixed- and low variable-costs. Unlike Earth-bound systems, space

projects require sponsors to put up all the money at the outset, and then find customers to validate the business plan. The magazine *Via Satellite* estimates that US$ 54 billion will be required between 1996 and 2000 to build and launch commercial communications satellite systems. That money will have to come from the private sector, since governments are largely absent from this field, and international consortia like INTELSAT and INMARSAT represent only a small portion of this sum.

The plain fact is that even governments are having trouble raising money for satellite projects, mostly of a research nature, which they have traditionally sponsored in the past. What we are seeing today is a geometric growth in the number and scope of private commercial satellite systems, most of which are communications-related. Euroconsult estimates that, in the next 10 years, satellite manufacturers will deliver 7-17 GEOs, 152 Big LEOs and 240 Little LEOs. To this, let us add another 84 GEOs and 840 LEOs for proposed Ka-band systems. The funds required are simply staggering, and I therefore have to believe that a number of the proposals currently on paper will never become a reality. Witness, for example, the recent decision by AT&T to withdraw its application to build the Voicespan system for, among other reasons, the "projected system cost."

Still, it is equally true that a good number of these systems can and will be funded. First, this is so because there is money for systems with a viable business plan and, second, because the world needs these systems as an integral foundation for basic telecommunications in the 21st century.

But funding of this magnitude is not just going to happen. It isn't going to just fall into place by magic. It has to be made to happen and it has to be managed. If I use the Big LEO and Little LEO systems as an example, and I do so only because they are the areas that I know best, the biggest single hurdle to implementation of the four competing Big LEO systems has been financial. All of the systems have proven to be more expensive than originally forecast, and the in-service dates have all had to be pushed back, in some cases by a number of years. Why? Because these systems are very expensive, and such sums have proved to be harder to raise than people first imagined. None of the four is yet fully funded, although some of the systems are very close to that objective. Only one of the Little LEO systems - Orbcomm - is fully funded, and even it has just two of its planned constellation of 28 satellites in operation.

Today, some of the most valuable members of these project teams are the financial and investment wizards. They provide advice on system funding, and

develop forward-looking financing scenarios that try to anticipate debt and equity market conditions years in advance, in order to come up with a financing plan which will yield the necessary dollars and, just as importantly, at the right time.

Financing has been a major challenge for all of the system operators. Yet, I believe that in a few years we will look back and consider that we have been rather lucky. The backers of the many proposed Ka-band systems will have far more competitors than the Big LEO and MEO systems, and it is a certainty that not all of the planned Ka-band systems will be built. Teledesic is a good example. This is a $9-plus billion LEO system - originally 840 satellites, plus spares, now reduced to 288 satellites but the same price tag. It involves no technical innovations, and building such a number of satellites will be a challenge indeed. But I believe that the financial challenges in raising such a sum far outweigh the technical challenges.

It is possible that some of the best systems, from a purely technical point of view, may never be built. This may seem a paradox, but the hard truth is that the financial markets are mostly insensitive to technology. You can have, for example, an innovative system and fail to find the requisite financing because the financial markets think the marketing plan is deficient. This insensitivity to technology will probably change in the future, as financial analysts become discriminating; then, system technology will be evaluated on its own merits.

History can teach us some important lessons, if we pay attention. For example, the first DBS system was proposed by Comsat in the early 1980's and, at the time, it was a wonderful technical idea - an engineer's dream. Too bad that it took digital compression of the early 1990's to make it a commercial reality! In the meantime Comsat lost over $80 million chasing this idea because no one was looking at it from the proper commercial perspective.

If the financial markets are indifferent to technology, so too are the end users. Customers generally don't care about system architecture, or much else besides service value, of which cost is one element. If a particular technology works as promised, and doesn't result in a cost penalty, then users will like it.

In the financial world, and the brave new world of commercial satellite systems, risk is everything. Systems which lower investor risk will nearly always be well received in the market. That's bad news for satellite system designers who want to position their projects at the leading edge of technology.

That's risky, and risky commercial systems are going to have trouble finding private capital.

Like it or not, space has become a competitive environment - competitive for customers and, as important, for funding. Thus, in a number of ways the financial satellite engineers already call the tune for the rest of their colleagues. They dictate, to a large degree, what is financable and what isn't. And, while they may stifle some engineering creativity, they challenge engineers to find lower cost solutions to problems, and to reduce as much as possible the risks associated with their creations.

So far, I have dealt with commercial systems. There is and will continue to be, I am confident, a very significant role for government agencies in the field of space. I trust that governments around the world will not be so distracted by everyday problems on Earth that they forget that the future of mankind lies in the stars. The world needs continued government participation in pure research and space exploration projects. Sometimes this can be done in conjunction with private capital, but the bulk of funding will originate from governments. Why? Because, if a project doesn't offer a tangible and adequate return on investment, businesses are not interested. That doesn't mean these projects aren't important - in fact, quite the contrary - it just means the funding is going to come from the public purse. A good analogy is the wave of European maritime exploration in the early 16th century. Considered too risky at the outset for private capital, it was government funding that allowed men like Columbus, da Gama, Cabot, Hudson, Cartier and Magellan to write their names in history books. Once these men - and others - proved that the risks were manageable, the way was opened for a flood of private ventures, most based on wringing a profit from the new frontier - gold, spices, silks and furs.

3. Education

Funding for space education is also important, and here also governments have a valuable role. In addition, governments have a collaborative role to play in space, and it is truly gratifying to find in space a prime example of multinational cooperation. The International Space Station - the first part of which is to be launched in October 1998 - comes immediately to mind. This is the largest international scientific and technical endeavor ever undertaken, and involves 13 nations. One reason for this cooperation may be that no one government has the financial resources - or the inclination - to do it all anymore. Construction of the Space Station is expected to cost over $9 billion, with running costs of $2 billion per year. Governments have recognized as well

that the challenges of space, truly Earth's last frontier, can only be met through international cooperation.

What does all this mean in practical terms, particularly to an institution of higher learning like ISU? First, it is important that such institutions build bridges between the technical streams and the commercial streams. No longer can they work in isolation. Now, I do not mean that we will have investment bankers making technical decisions, or that system designers will make funding pitches to Wall Street or City bankers. Clearly, though, each side needs to know more about the other's activities and constraints. This is something that ISU could consider strengthening in its curriculum, and such a move could help differentiate ISU from other institutions. Second, satellite system designers need to understand the new realities of commercial space. The first of those realities is: if it can't be financed, it won't be built. Everything else flows from this.

Session 5

Teleservices

Session Chair:

H. Chasia, Deputy Secretary General, ITU

A Commercial Satellite-University Joint Venture in DBS Markets: Creating Future Tele-education Markets Via Satellite

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Abstract

Nations recognize the need to invest in education and to develop productive citizens for national and local communities; most require mandatory schooling. In developing nations, satellite technology has the capacity to reach teachers in remote and educationally deficient areas contributing to improved teaching skills and productivity.

This paper describes the experience of consultants and university administrators in their attempt to design a Venezuelan direct broadcast satellite infrastructure for the training of preschool, primary, and middle school teachers. Satellites combined with multipoint compressed video and fiberoptic terrestrial links extend the educational parameters of the nation state. Wireless and digital technologies provide affordable communication infrastructures to answer the need for individual access and convenience. This paper describes a joint venture experiment in distance education and emphasizes potential viable opportunities of global tele-education developments in an exciting new space market. This project is one of the first examples being explored by Project LEARN of the International Space University (Reference 1).

1. Introduction

"We now realize that knowledge is the most important economic resource, vital for the competitiveness of individuals, enterprises and nations" (Reference 2). In a time of paradigm shift and fiscal restrictions, the question is "how can we afford knowledge, and, paradoxically, can we afford not to have it?" This is the dilemma of education. For all of us, each individual is one of the most precious assets of a nation. Therefore, "investing in our children is investing in the future of humanity" (Reference 3). At a time when the satellite industry has a plan to spend more than $20 billion to extend modern communications services such as telephony, video programming, and computer network to remote areas (Reference 4), when China plans to use satellite and distance education to provide literacy to 400 million of its citizens (Reference 5), when "...direct broadcast satellite (DBS) systems have currently outsold every other electronic product ever produced..." (Reference 6), when new technologies are changing the face of global telecommunications and growing by more than 20% a year, when companies like Starbuck Coffee are becoming "learning organizations" (skills and knowledge development through on-going training) by implementing "Learning Councils", it is imperative that both countries and organizations realize their potential and seize the opportunities

offered by telecommunications to increase market share and to invest in their employees' future.

After acknowledging a new paradigm, a proliferation of definitions and opportunities, we examine the Venezuelan Proposal and discuss the need to overcome the most stubborn barrier, our own resistance to change.

2. Paradigm Shift

American author and physicist Oliver Wendell Holmes said: "I find the great thing in this world is not so much where we stand, as in what direction we are moving..." We are reminded of the need for a vision of the future for our planet, our continents, our countries, our cities and our local communities. Are we communicating together and pushing for progress, or are most of us fighting selfishly to prevent others from gaining access to knowledge, quality of life, and riches?

The operative word is "COMMUNICATING". In developing a vision of the future, communications are the sine qua non condition for progress in society; we cannot improve the economic condition of the more than 9 billion people expected to inhabit this Earth by 2030 without communicating (Reference 1). Our collective wellbeing depends on the ability of industrialized nations to help developing nations. Productive, informed citizens contribute to the expansion of the human mind, the development of the Earth, the exploration of space and the solar system. There are as many visions as there are dreams. However, to be realized, our collective vision must meet the needs of our present concerns. Following a master plan fitting the vision developed by the protagonists of a project, visions can be achieved only in partnership with other individuals, organizations, countries, regional and global entities.

Given the state of technology today, it is reasonable to assume that, in the near future, everyone will be connected interactively whether by cable, fiber, wireless or satellite (Reference 7). "Knowledge webs" (Reference 8) will constitute the core of "distributed learning"; "virtual communities" will be created, gathering individuals in their interest loci rather than in their physical location. If we build joint ventures leading to a better future for our worldwide children, the tremendous impact of this network of ideas, of virtual communities, and artificial intelligence will benefit all of us.

Only our limited minds can prevent us from experiencing this paradigm shift. The Net and the Web are building cyberspace communities and linkages

at a logarithmic pace. Fiber optic highways are crisscrossing our industrialized countries, reaching out to the remote corners of the five continents. Local Area Networks (LAN), Metropolitan Area Networks (MAN), and Wide Area Networks (WAN) are overlapping in experiments; networks of exchange are creating the architecture for future human development. Communications are creating National Information Infrastructures (NII) and blossoming into a Global Information Infrastructure (GII). All of this empowers individuals. Their content is market driven. The protocols and rules are still minimal. The energy generated is phenomenal, and we are only in the infancy of the communications age! INTELSAT Early Bird was launched in April 1965; Arpanet started in 1969. Fiber optic technology is more recent. The U.S. National Information Infrastructure (NII) was announced in 1993. Growing pains will occur. Because technology is neutral, we must harness it to "achieve a productive and creative symbiosis..." or, to use the vivid description of Pelton (Reference 9), are condemned to "...dancing the dance of the dinosaurs".

3. A Semantic Mess

Satellite communications as a carrier for educational purposes have many formats as witnessed by this semantic explosion: Open University, Open Learning, Distance Learning, Distance Education, Distributed Learning, Asynchronous Transfer Mode, Independent Study, On-line Education, Tele-learning, Tele-education, Computer Mediated Instruction, Computer Based Instruction, Flexible Delivery, Audiographics, Audioconferencing, Videoconferencing, Teleconferencing courses, etc.. Whatever the definition and the format, their common ground is the use of one technology or multiple technologies called interfaces. These interfaces bridge the time and physical distance between the student and the professor, the student and the content, and students and other students. Therefore, the delivery of learning is mediated through one or more technologies, to achieve what the chalk on the blackboard tried to accomplish in the traditional classroom. We are talking of "Technology Mediated Instruction or Education" (Reference 10). Each of these technologies is a better match for certain contents and achieves a greater acceptance with students and faculty. Given the convergence of the technologies, and the versatility of the satellite communications to cover entire regions, we have the opportunity to reach out "boldly where no man went before", to paraphrase a well known science fiction show. Now, we can, and should, teach the world.

4. Opportunities for New Markets

Satellite communications open new windows of opportunity. In their recommendations to the European Council, the Members of the High-Level Group on the Information Society (Reference 11) enumerated ten applications/opportunities to link countries of the European Community. They are teleworking or telecommuting, distance learning, a network for universities and research centers, telematic services for Small and Medium Enterprises (SME's), road traffic management, air traffic control, healthcare networks, electronic tendering (administrative transactions), trans-European public administration network, and city information network. Most of these applications represent potential markets for satellite communication. Through teleports and terrestrial connections, the European network has the capability to reach very remote areas. Furthermore, similar applications can be implemented in other geographic areas such as the Caribbean, Central and South America, Africa, Asia and Oceania. For the purpose of this paper, and in the spirit of ISU's Project LEARN (Reference 1), we consider Venezuela.

5. The Venezuelan Proposal

Venezuela has received approval for a World Bank loan of $ 1.2 billion for health, transportation, community, and education infrastructures. Upon acceptance by the World Bank of suitable projects, part of the funding was to be released. Moreover, contingent upon World Bank financing of the telecommunications infrastructure, Galaxy Latin America, at a World Bank meeting in Mexico in October 1996, offered one year of satellite time to developing countries, exclusively for educational purposes. With these important developments, the Executive Director of the Inter-American Consortium for Distance Education (CREAD) and the President of the Universidad Simon Rodriguez (USR) of Caracas agreed to develop a project to take advantage of the generous offer. They recruited consultants from Washington, D.C., Oklahoma and Miami to identify needs and recommend a course of action.

The background of the proposal is as follows: A Venezuelan scholar/researcher Barrios Yaselli (Reference 12) from Universidad Pedagogica Experimental Libertador (UPEL) predicted an acute shortage of 16,787 teachers from pre- to middle schools by the year 2001. This crisis was attributed to teachers' retirement and attrition along with an increase in student enrollment. Moreover, new teachers were insufficient in number to fill the available positions; teachers without proper credentials were hired to

meet the demand. Furthermore, distance was a critical factor: the greater the distance from the Venezuelan Capital, the higher the number of undocumented teachers.

Three objectives were agreed upon:

- create a Distance Learning Network closer to the workplace, using new technologies, to teach and train teachers and auxiliaries;
- raise the degree completion rate and in-service training skills for non-degree and degree teachers, and
- improve the general educational level of teachers and their level of specialization.

Diagnostics and remediation were somewhat easy. However, the implementation and planning of the agreed objectives did not come quickly. To succeed, and to convince the World Bank of the importance of the project, other participants had to be included: The Ministry of Education and related Departments, UPEL, Universidad Simon Bolivar (USB), Universidad Nacional a Distancia (UNA), IBM-Venezuela, CANTV, and REACCIUN, the public universities Internet network (Reference 13). Having public and private participants agree and share a common vision was a tremendous challenge. Moreover, the consultants soon discovered that success of the project depended on a number of conditions: the expertise and perceptions of the stakeholders, i.e. on their public/private definitions of distance learning, their assumptions regarding the available resources, and the greater access, efficiency, affordability, and dependability criteria as required by the World Bank.

The consultants' evaluation of existing infrastructures and conditions of operation was arduous and was dependent on a paucity of reliable data. Within the main cities, the communications infrastructures were accessible and generally acceptable. For example, fiber optic links were in place in coastal cities from Cumana to Coro, IBM had its own ATM network, and CANTV was involved in the recent establishment of the public university Internet network REACCIUN. And despite the huge investments and improvements achieved by the General Telephone & Electric (GTE) led consortium, cellular telephones were more popular than the traditional telephone lines.

Furthermore, once public/private participants were involved in the planning process, USR representatives and Education Department officials focused on the content of the project, and the private enterprises focused on hardware considerations. As expected, the content had to be designed to suit

the technology mediated instruction delivery. Strategic decisions had to be agreed upon, including should a consortium be formed or the territory divided according to the existing facilities available for each of the universities? Who should lead, and how should the implementation of the project be staged? Are textbooks available, and how do we distribute the printed material? From the user's perspective, how do they access the technology, and what support services are they expecting? How are the trainers and the facilitators trained? What physical facilities will be available; will they be upgradable, low tech or high tech? Finally, the consultants were asked to design the infrastructure or, at least, to suggest an architecture congruent with these parameters.

Because of the absence of a reliable communications infrastructure in the remote areas, and for practical and economical reasons, satellite delivery was the first decision unanimously agreed upon. Where telephone lines would allow, fax and phone communications would be expected to provide interactivity and feedback needed to keep the students and teachers motivated. Teleports had to be built in rural centers to allow for decentralization of the network. In the first phase of the project, origination sites would be limited to three and would originate programming. Coordination had to be functional and related to the expertise and human resources of the local participants.

To allow for back up capabilities, should a breakdown of terrestrial communications occur, in addition to recommending the use of Galaxy as the carrier, redundancies were suggested. The network configuration was designed to mimic the organization of the university: Headquarters (origination site), Decanatus (regional centers), Nucleos (sub-centers), and finally the schools. When cable or broadcast facilities were available, they would be integrated into the network. More importantly, the Universidad National a Distancia (UNA) ITV network would participate in the process (Reference 13). Integration of voice, data, and video for distance learning necessitates partnership with local technology stakeholders. They would, in cooperation with the universities, be expected to develop the local expertise to manage the project and take advantage of the new capabilities of the network. Further, they are expected to contribute to the financing of the educational needs of the country.

6. Firewalls to Market Entry

In the jargon of the computer field, firewalls are barriers or obstacles raised to prevent hackers from breaking into computer databases. Similarly, if

breaking into the satellite delivery mode seems so simple, why are our suggestions or recommendations not implemented immediately and within a reasonable timeline? As consultants, we can only speculate as to what can happen, or has happened, in other projects. While it seems that the costs and the technological capabilities are not paramount in this project, the acceptance of technology, its access on all the territories, the cultural and policy aspects, the various assumptions, both explicit and implicit, of the participants to the system, the product itself, the socio-economic motivations, the staffing and training of the trainers, as well as the Ministry's, and administrative, support will impact on the success of the project.

7. Concluding Remarks

One Venezuelan Proposal is being reviewed by the government. In March 1997, the faculty of the Venezuelan universities ended a three month strike which brought the entire Higher Education system to a halt. Disappointed that resources were being wasted, the World Bank threatened to reclaim the loan from the country, if a decision were not made soon. Other stakeholders are waiting for the administrative and academic units to resolve the urgent matter of graduating more teachers every year. The value of the project is not in question. Negotiations are lengthy and the process is slow.

However, in the spirit of Project LEARN, we are reminded that similar initiatives can be replicated in other developing countries facing teacher shortfalls. Projects such as TI-IN (private satellite network for K-12 and professional developement) and Schola in the USA have demonstrated the benefits of using satellite communications to reach out to the nations of the world. EuroPACE is an example of the complications inherent in the development of viable self-sustaining educational programs. Without question, we are at the threshold of Virtual Universities and Global Learning Centers. Cooperative ventures between private and public organizations provide regional and nationwide delivery systems to the benefit of all students.

It is always frustrating to observe organizations hurt their survival chances by implementing poor choices, as they stray from potentially better solutions. Technologies are not the panacea to solve all our problems. However, tremendous technological capabilities are available to us; human reluctance to embrace these innovations, and change the way in which we do things, is the challenge of progress. Countries like Venezuela are "destined to leapfrog" (Reference 2) into the 21st Century. Time will tell.

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Trends Toward the Development of a New Potential Space Market Providing Satellite Based Telemedical Services

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Abstract

Telemedicine can be defined as the use of telecommunications and computer technologies with medical expertise to facilitate remote health care delivery, and its goal is to provide higher quality health care at a lower cost. Medically related services that can be provided by telemedicine are endless and include teleconsultation for isolated or remote sites, transfer of patient data and files, tele-education for medical students and continuing medical education (CME) for doctors, medical support during emergency or disaster relief, at-home patient monitoring, administration, and medical conferences. Until recently, several barriers have prevented a more rapid expansion of telemedical applications and particularly the development of a market providing telemedical services. The value of telemedical applications has been poorly understood and not completely appreciated by the general public, and therefore has not enjoyed as much support as it should have.

Recently, the use of telemedicine has seen a significant reduction in cost, an improvement in technology, an increase in its awareness and appreciation, and more experience in its implementation. With the increasing interest in telemedicine in combination with numerous reports of successful telemedical projects, it is expected that telemedicine will be more widely appreciated, accepted, and subsequently applied in everyday medicine. The need for specialized dedicated telemedical services in the near future is evident and the potential for the development of a new space market is real. This paper investigates the role of satellite systems in telemedicine and the features of a new potential space based market in providing telemedical services. This is accomplished by analyzing current trends in telemedicine with reference to cost, technology, availability, law and policy, public awareness, and experience. Medical services that can be provided by telemedicine and the potential savings in using such services are also discussed.

1. Introduction

The basic concept of telemedicine has been around for decades. Whenever a doctor uses the telephone to give or receive information about a patient, he/she is using telemedicine. In fact, telemedicine can be traced back to the 1920s, when radio was used by physicians assisting ships at sea during medical emergencies. The current concept of applying space-based satellites for telemedical applications began in the 1970s with projects like those in Alaskan and Canadian villages where the ATS-6 satellite linked hospitals in distant towns and cities. Since then, many pilot and demonstration projects have been instituted to test the feasibility of applying telemedicine into medical practice. Almost all of these early projects were funded by governments. These programs placed little emphasis on cost-effectiveness, but rather focused on

application. As funding for various programs was cut, these programs could no longer sustain themselves financially.

Telemedical services can be provided by either ground networks or space-based satellite systems. Although these two types of systems can be mutually complementary, there are fundamental differences between them. Currently, ground networks are more extensively used because of the greater availability and cheaper cost, but the drawbacks are that some of their capabilities are limited with respect to satellite systems. The problem with satellite systems is that their use is expensive, as is the ground and end user equipment. With improvements in telecommunications and satellite technologies, the cost of using satellites for transmissions is decreasing.

There have been several barriers which have prevented a more rapid expansion of telemedicine. Generally, these barriers can be divided into technical and non-technical barriers. Technical barriers are closely associated with both cost issues and technical capabilities. Real-time transmission of high quality images or motion video requires large bandwidths. The terminal equipment for traditional ground networks has been expensive and geosynchronous (GEO) satellite systems have unacceptable time delays. Non-technical barriers include regulatory barriers. Because telemedicine was a new concept in the beginning, many of the existing policies and laws were inadequate. Some of the concerns associated with the use of telemedicine include issues of malpractice, licensure when practicing "in" states where a doctor is not licensed, and patient confidentiality.

Telemedicine projects involve an extremely large number of people, equipment, and expertise. With the lack of experience, few people had a clear idea of how to run a telemedicine project efficiently. Many of the earlier projects were conducted on a trial basis. The organizational difficulties and uncertainties have also contributed to the apprehension towards applying telemedicine.

2. What is the Telemedicine Market?

Because the widespread use of telemedicine is still not upon us, the telemedicine market is still in the evolutionary stages. Unlike well established markets, the key players and their roles are not clearly defined. Essentially, the telemedicine market is made up of the consumers (i.e. the users of telemedicine) and the providers. The providers supply either the equipment and capacity necessary for carrying out telemedicine and/or provide services for

its implementation. As the advantages and practicality of telemedicine become more apparent, the use of telemedicine in common medical practice will increase. The users of telemedicine are on the rise. This increase in consumer demand will require the development of equipment and services which have more capabilities, are more efficient and are much cheaper.

The market can be roughly divided into three segments. The space and ground segment include providers of bandwidth and transmission capabilities, whether they be through space-based satellites or ground-based cables. This segment also includes the ground infrastructure for satellites. The second segment involves companies that provide the end user equipment used for telemedicine. The final and least developed segment is the telemedicine services market. This market has still to be clearly defined because there has been little need for such services. Because many of the barriers to the expansion of telemedicine are being eliminated, the need for special services for telemedicine are becoming more obvious.

Most telemedicine projects to date have been implemented by individual hospitals or already established hospital networks, and have been largely independent of each other. The satellite or terrestrial telecommunication links have been arranged directly by the users with various companies that provide such services. Because the arrangements have been done on a case by case basis, the costs of these projects vary from one to another, and are larger than if many users had come together to purchase more capacity all at once. There are many companies that sell specialized equipment especially for the use of telemedicine.

The idea of a market that provides specialized services for telemedicine is relatively new. Companies that would provide such services would act as intermediaries between the users and the telecommunications and equipment supplier companies. These intermediary companies would be in an ideal position to identify and attract potential users of telemedicine. With a large enough consumer base, large amounts of bandwidth can be purchased and specialized contracts made with suppliers that would be beneficial to all parties involved. Because telemedicine has been in the experimental stage, such a services market was clearly unnecessary, but current trends will warrant the development of such a market. Given the technological and non-technological trends in telemedicine, this segment of the market has the potential to rapidly grow in the coming years.

3. Uses of Telemedicine

There are numerous applications for telecommunications in medicine. Most of these applications are not only practical and can increase the quality of health care being provided but, more importantly, can significantly reduce the cost of delivering such health care. These medical applications can be broadly divided into the following categories:

3.1 Monitoring

Telemedicine can be used for monitoring of patients at home or at remote clinics so that they do not have to remain in hospitals or have nurses take care of them at home. Home health care is a rapidly growing market in medicine. This is partly due to increased pressures to reduce health care costs by reducing the number of days that patients stay in hospitals. Frequent visits by health care providers to patients' homes can be reduced by applying telemedicine for procedures that are routine and do not require direct intervention by a health care provider.

3.2 Consultation

It is not uncommon for patients to see more than one physician before receiving a diagnosis and/or treatment for a medical condition. Because certain cases require the expertise of specialists, patients are often referred to these specialty physicians for further evaluation. Sometimes, the physician directly consults the specialists for their expert advice. This can be done either by having the specialist physically come to the where the patient is or by contacting him/her by phone. The disadvantages of referring the patient or having the specialist come are clear; there is a loss of valuable time and money. In addition, the specialist may be located very far away and direct interaction could require extensive traveling. On the other hand, consultation over the telephone has its obvious limitations as well. Telemedicine can alleviate these limitations by allowing the specialist to see the patient directly and even interact with him/her. Pertinent patient information can also be quickly transmitted for use. Another advantage of telemedicine is that several physicians from various locations can take part simultaneously in a consultation.

3.3 *Diagnosis*

Diagnosis of medical conditions using telemedicine is very similar to consultation. Here, a physician need not physically be with the patient. Particularly with remote locations, it may not be practically feasible for a physician to be present. In such cases, other health care providers can directly contact a physician who can conduct most parts of a medical examination with the aid of the health care provider. A reliable medical diagnosis can be made using specialized equipment that would allow the physician to see virtually everything that would be seen normally.

3.4 *Transfer of Patient Information*

Telemedicine can provide easy and efficient access to patient information and data. Most patient information is recorded on paper charts and kept in folders. There may be incomplete data located in different hospitals and clinics. Telemedicine would allow for the easy transmission and consolidation of these data. Other forms of data such as X-rays, CT and MRI scans, and ultrasound images can also be stored and transmitted. The amount of time and money that could be saved using telemedicine rather than traditional methods of postal delivery could be enormous.

3.5 *Administration*

Telemedicine can greatly increase the efficiency of hospital networks. Clinics at remote or distant sites can be easily integrated into the activities of the main hospital through telemedicine.

3.6 *Education*

Health care providers, including physicians, are required to keep up with medical information. One way this is accomplished is through educational lectures or courses which must be attended on a regularly basis, such as is done with continuing medical education (CME) for doctors in the US. Unless these events take place close to where the health care providers are located, it may require long trips in order to attend. In some locations, the remoteness may in fact prevent this. Telemedicine can allow these health care providers to take part in such courses remotely. In addition, telemedicine can be applied to medical school teaching whereby multiple teaching hospital sites can participate in teaching medical students interactively.

3.7 Professional Contact

Particularly for those physicians that are at remote sites, professional isolation can be very damaging. Telemedicine can significantly reduce this sense of isolation by readily allowing contact with other members of the medical community.

4. Non-Technical Barriers to Telemedicine

4.1 Legal and Regulatory

There are several legal and regulatory issues that must be resolved before telemedicine can grow to its full potential. The current situation is ill-equipped to deal with the new issues which arise out of the use of telemedicine in medical practice. Although the following issues still remain to be resolved, they are being addressed and solutions are being discussed by the medical community involved.

In most countries, physicians must be licensed by designated authorities in order to practice legally in that country. In the US, only physicians with a license from a particular state can practice in that state. The problem arises in telemedicine when physicians from different states are involved in telediagnosis or teleconsultation. Even though the physicians may not physically be in the state, by virtue of the fact that they are treating a patient in that state would they need to be licensed in that state? If so, this can be a serious setback for the widespread application of telemedicine for such use.

Liability is another multifaceted issue which must be addressed in telemedicine. In general, this refers to cases when the health care provided is of inadequate or questionable quality. Issues which arise include the definition of when a physician-patient relationship is established, the risk involved in using the technology, the person or party responsible in the case of misdiagnosis due to a failure in any part of the telemedicine system, and professional liability insurance policies.

Patient confidentiality and privacy are of paramount importance in the practice of medicine. There is a risk that, with the use of telemedicine, this may be compromised. Before there can be well accepted assurance that this would not occur, there must be standards for ways of assuring patient confidentiality and privacy.

4.2 Acceptance

There has been much resistance from many people in implementing telemedicine, usually arising out of an uncertainty about the technology. Particularly with older physicians, there is reluctance to implement such previously unproven technologies and methods. The best way to alleviate this uncertainty is to educate and train potential users so that they understand and appreciate not only the benefits of telemedicine but also some of the technical aspects as well.

Cultural beliefs may make some physicians and patients reluctant to embrace telemedicine as they may only have confidence in medical treatments when they are in direct contact with each other. Prolonged successful telemedical applications and telemedical education to both patients and physicians may help to improve the users' perception of telemedicine.

4.3 Experience

Experience in the uses of telemedicine and their cost-effectiveness is only just becoming evident. Most past and currently existing telemedicine projects have been implemented as pilot projects or on a trial basis so that greater experience can be gained before considering a more widespread application of the technology. These projects have given insight into the cost-saving potential of telemedicine as well as its new applications.

4.4 Awareness

Part of the reason that telemedicine has not been more widely implemented is simply that many people are not aware of its benefits or even its existence. As more projects emerge and with the creation of dedicated telemedicine journals and conferences, telemedicine is gaining more attention and acceptance.

5. Technical Barriers to Telemedicine

5.1 Telecommunications Considerations

Depending on the type of telemedical service, the bandwidth requirement for transmission over the telecommunication network will vary and it is this bandwidth that will determine the cost of the telemedical service. High

resolution video transmission requires large bandwidth. Compression techniques are imperative.

The public switched telecommunication network (PSTN) exchanges are currently not able to switch high data rate signals such as video data. This severely limits its ability to provide interactive video service which would be essential for a successful telemedical service.

Using GEO satellites, the time delay of 274 msec is unacceptable for some telemedical applications. The large Earth terminal equipment used to communicate through GEO satellites is very expensive and cannot be installed at hospital premises for dedicated telemedical purposes. Although Very Small Aperture Terminals (VSAT) could be seen as a good alternative, they still cannot be used for high data rates, and time delays remain a big problem for certain telemedical applications.

6. Trends Toward the Breakdown of Non-Technical Barriers

The growing number of telemedicine projects and reports about their success and findings have helped in increasing the awareness of the many advantages of telemedicine. Many of the trial projects have tested various applications in different fields of medicine. New equipment has been tried as well. The experience gained improving the quality of health care and also making it more cost-effective has added to the credibility of telemedicine in the eyes of the medical community.

With the rapid increase in the number of telemedicine projects and also with more organizations established for the promotion of telemedicine, it is expected that the legal and regulatory issues will be addressed. However, considerable time will be required.

7. Trends Toward the Breakdown of Technical Barriers

The emergence of new technologies has made it feasible to operate satellite constellations in LEO for communications services which previously had not been possible. The introduction of integrated services digital networks (ISDN), multimedia and high speed switching technology, such as asynchronous transfer mode (ATM), will allow for a more rapid expansion of the telemedicine market. The new mobile satellite communication constellations in LEO not only have a small delay time (about 5 msec), but they also eliminate the need for a local loop at the end users' premises. Therefore,

the use of telemedical services in remote and disaster areas would be easily realizable. The small Earth terminals would not only be less expensive than the corresponding counterparts for the GEO satellites but also be more flexibile. There is sufficient bandwidth in some of the constellations, such as Teledesic, to transmit video, voice and data. ISDN and multimedia technologies for telemedicine applications imply that the same switching equipment be used to switch voice, video and data at the same time.

New compression techniques are making imaging possible, and using multimedia interactive telemedicine is possible. A number of medical parameters that require real-time transmission, such as Doppler spectral or auditory information, high resolution images and still images, are now possible from the technological viewpoint.

8. Conclusion

Given these new trends, it is expected that telemedicine will become more widely used in common medical practice. If current rates of increase in the number of telemedical projects continues, it will not be long before almost all Western hospitals have some form of advanced telemedical systems. Because of the advantages of satellite-based telemedicine in being able to connect remote and underserved sites at relatively low rates, telemedicine can also have a large impact in developing countries as well. This great increase in the number users will create the need for a telemedical services market. This market would involve the provision of special services in telemedicine as well as provide an economical way of distributing telecommunication links and selling end user equipment.

Space Assets in the Emerging Telemedicine Market

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Abstract

Governments have played a key role in demonstrating through pilot projects the feasibility and the validity of the telemedicine concept, a new way to deliver health care. However, more and more private projects are now being initiated and the role of governments evolves to support the private initiatives of telecommunications companies, healthcare centers, or international organizations.

Space industries have accumulated extensive experience of telemedicine over almost forty years of manned space flights, and could be an important interface between the medical fields, telecommunications suppliers and information technologies. Worldwide cover, total accessibility, mobility, flexibility and reliability are also key assets of space communications which represent the added value of space in the telemedicine market. Space industries have to go ahead, working in cooperation with physicians to provide the telemedicine market with services fitting the users' needs.

1. Introduction

Telemedicine is conceived as an integrated system of distant healthcare delivery. This system uses telecommunications and computer technology as a substitute to the traditional face-to-face contact between the patient and the practitioner. Telemedicine systems have been from the beginning initiated by national or international public authorities to meet specific needs: an ever growing demand for healthcare regardless of the geographic localisation (remote or very low population density areas) and a demand with diversified origins (ships, off-shore platforms, natural disasters, warfare context, etc.).

The development of telemedicine system relied mostly, up to now, on public initiatives. Nevertheless, if telemedicine is to play a significant role in the delivery of medical care, some private initiatives are essential and necessary. Some already exist, mainly iniated by telecommunications companies. The implementation of telemedicine systems implies the development of new competences and new relations between the different agents acting in these systems (patient, practitioner, hospital, government). The public initiatives have demonstrated the validity of the concept and the feasibility of the implementation of telemedicine systems. Even if the development of telemedicine systems will rely increasingly on private initiatives, the governments still have an important role to play in the identification and the

removal of the obstacles preventing the successful development of telemedicine systems.

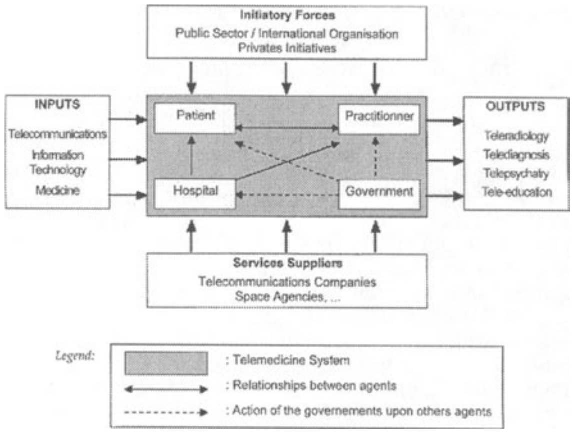

Figure 1. Description of a telemedicine system

In this new way to deliver health care, space can play a key role. Telemedicine has been extensively experimented with to meet with the severe requirements of manned space flights and space telecommunications own key assets which could be of great value in this new market.

2. Competence Building and the Importance of Public Policy

Telemedicine is not a new basic subject of medicine but rather a new way to deliver healthcare. Nevertheless its development will induce tremendous changes in the functions and interrelations of the actors of the medical sector. Telemedicine will obviously cause great changes in the relations between the patient and the practitioner, and between the practitioners themselves. It will also interfere with the public policy concerning the medical sector. The main beneficiaries of the development of telemedicine systems are the patients or the general public. Telemedicine has the potential to offer great improvements in the quality of the healthcare delivery at different levels (see Table 1).

Both practitioners and patients will have to acquire new competences to cope with the dramatic changes induced by a telemedicine system. In a telemedicine system, the patient can play two different roles. The first case

does not represent important changes for him; a general practitioner or a nurse acts as an interface between the patient and the specialist using a telemedicine network. The examination is carried out in cooperation with the competent people on site and the remote specialist, who will then deliver his diagnosis and support the practitioner on site in his treatment, and the patient remains in a passive role. The second case is one in which the patient has a much more active role. For people in remote areas, requiring frequent routine visits or in cases of emergency, a direct telemedicine link can be established between the patient and the practitioner. In that case, the patient has both to be trained to use the equipment but also, guided by the practitioner, to realize his self-diagnosis and transmit the information to the practitioner.

Patients	Practitioners	Hospitals
• access to healthcare for remote areas • savings in time and money (travel, work days) • easier access to specialist	• improved communications • continuous education and training • break up of geographical barriers	• efficient management of patient data • quicker and more accurate diagnosis • better use of equipment

Table 1. Improvements in the quality of healthcare delivery using telemedicine

The practitioner will have to acquire new work methods, using sophisticated hardware, involving telecommunication and computer technologies. The weakest point of telemedicine systems remains the man/machine interface. For an easy and efficient application of telemedicine, the technological aspects have to be simplified to become much more user friendly. The implementation of telemedicine systems will also provide hospitals with powerful tools. Nevertheless the implementation of such systems will be very costly and thought should be given to the new role of the hospitals in a telemedicine context (see Table 1). Should all hospitals be equipped with all aspects of telemedicine? Should some hospitals be more specialized in certain aspects of telemedicine and rely on a telemedicine network for the other aspects? Some of the answers to these questions are highly linked with the role of the government and the decisions that will be taken at a political level. In the development of telemedicine, the role of government is twofold. On the one hand, the public authorities have been and are still very active in demonstrating, through pilot projects, the technical and economical feasibility, and strength, of telemedicine. On the other hand the Government has to identify and remove the obstacles preventing the successful

development of telemedicine. The obstacles can be classified in three main categories shown in Table 2.

Legal obstacles	Market uncertainty	Lack of standards
• license system based on a state based approach • confidentiality, integrity and access to patients data	• Physicians not yet convinced • Uncertain return on investment • further government support not certain	• lack of technical standards • lack of clinical standards

Table 2. Obstacles preventing a successful development of telemedicine

In order to cope with all these uncertainties, a global approach has been adopted in Europe. This approach is based on agreed strategic guidelines at the European level and a series of programs fostering the development of telemedicine at both international and national levels.

3. From Public to Private: A Survey of Telemedicine Initiatives

The first telemedicine projects were defined in the United States at the end of the 1950's. The primary objective was to serve the population with a limited access to healthcare. However, the most ambitious and efficient projects have been developed by the Department of Defense (DoD) in cooperation with the National Aeronautics and Space Administration (NASA). Great developments have been realized for military purposes, nevertheless two trends have been recently observed in the United States. More and more civilian projects are initiated and more and more projects are moving from a pilot phase to an operational phase.

In Europe, the relatively high density of population has weakened the initial willingness to invest in the development of telemedicine. The first countries which understood the potential of telemedicine systems were Norway and Greece, whose populations live in isolated or remote areas. Nevertheless, at the end of the 1980's, the European Commission initiated a series of programs to foster the development of telemedicine in Europe. The European approach attempts to create the necessary conditions for the development of telemedicine at a European level rather than demonstrating the value of these concepts through pilot projects. The programs insist that technologies are developed for healthcare delivery, and the harmonization of European standards, with

support being provided to any organization involved in the development of telemedicine systems.

The purpose of the Advanced Informatics in Medicine (AIM) program, initiated in 1989, is to define a European approach for the medical technologies and the telecommunications means. Its objectives are to stimulate the development of harmonized applications of medical and telecommunications technologies in healthcare, and to stimulate the development of an information infrastructure for European Healthcare, taking into account the users needs and the technological opportunities. The public policy in Europe concerning telemedicine appears to be more oriented towards civilian applications of telemedicine than in the United States. Moreover, the action is more concerned with the creation of propitious conditions for the emergence of telemedicine than with a large demonstration project.

Besides the action of the governments, more and more private projects are being initiated, mainly by telecommunications or health care organizations.

- Intelsat initiated the Satellites in Health and Rural Education (SHARE, 1985) in cooperation with Téléglobe Canada, the Kenyan and Ugandan Post and Telegraph companies, and the Toronto hospital.
- The telemedicine and Educational Technology Resources Agency (TETRA) is a successful project initiated by the Medicine department of the University of Newfoundland (Canada)/(see Reference 9).
- SatelLife is one of the most active Non Governmental Organization in the telemedicine area. The purpose of this organization, created in 1989, is to develop the exchange of medical information between developed and developing countries.
- The Global Emergency telemedicine Service project (GETS) is developed by Matra Marconi Space (MMS) in cooperation with the hospitals of Toulouse (France) and supported by the European Institute of telemedicine. GETS is an international emergency system aiming at improving the speed and efficiency of interventions.

This last example illustrates what could be a scenario of the evolution of the supply side on the telemedicine market. As already mentioned, most of the telemedicine projects are developed by Telecommunications or Healthcare Organizations. Telemedicine is between these two economic sectors, relying on the competences of both of them. On the one hand, telecommunications companies are working in a market which is quite unknown to them and, on the other hand, Healthcare organizations need telecommunications services to

develop telemedicine systems. New organizational structures, dedicated to the implementation of telemedicine services, could emerge, interfacing between the telecommunications supply and the medical needs.

4. Space Assets in This New Market

Telemedicine is a bridge between the space sector and the medical sector. Many projects have been developed in the framework of space missions. The constraints related to healthcare delivery in remote or isolated areas are very much like those related to medical assistance and support for biological or human physiology experiments conducted on board the Mir space station or the US Space Shuttle. Beyond the utilization of space communications, the space sector has a unique experience of telemedicine that should be highlighted and valued. The space industries have developed equipment and man/machine interfaces which enable physiological parameters to be measured, registered and transmited in real time. Such equipment as well as the procedures and the specific know-how accumulated could obviously be applied for non-space telemedicine projects. The association for the promotion of the use of space research and technology for medicine and life sciences (PROMEDUS) aims at developing and stimulating these interactions. This association initiated by the European Space Agency (ESA) groups together physicians, researchers and biomedical engineers on the one hand and space engineers on the other hand in order to increase the mutual understanding of these two domains, and to foster the application of space technologies in the medical field. This initiative is a good example of what needs to be done to enable space to play a key role in the emergence of interfaces between telecommunications, information technologies and the medical field.

Space telecommunications will not constitute the unique solution to the specific telemedicine telecommunications requirements, but should obviously be part of the solution. The traditional hardwire links can transmit telemedicine information at a very cheap rate and could be extensively used for certain types of telemedicine services in urban areas. These networks are extensively developed in high population density areas but, in low population density or isolated areas, they are absent. This handicap is major one as one of the purposes of telemedicine is to provide this type of geographic area with better healthcare delivery. Another problem is related to the insufficient reliability of this system. The risk of a wire breaking is too high to base a complete telemedicine system on a wire network. Some applications such as tele-surgery require much more reliability. Optic fibers are the usual competitors of space systems, and telemedicine is no exception. Optic fibers are very reliable,

resistant to interference, and have a very high data rate. Moreover, the price of using fiber optics is relatively low. Nevertheless, they have some disadvantages quite similar to these wire lines. Many regions are not yet equipped with fiber optics, especially those where telemedicine could have an important impact (remote areas, low population density areas, developing countries). Satellite communications present some characteristics which properly match some specific requirements of telemedicine services:

- Worldwide cover: as an autonomous system or as a complement of independent wires or optic fiber networks, communications satellites enable regional telemedicine services to be interconnected or worldwide services, as planned in the GETS project, to be developed.
- Total accessibility: any sites, even remote and isolated areas, such as in deserts, mountains, islands, off-shore platforms, etc., can be connected with hospitals or healthcare centers via communications satellites. With low Earth orbit satellite communications satellites systems, the ground segment has less stringent power requirements, which makes possible the use of small, portable and inexpensive ground terminals.
- Mobility: Mobile platforms can transmit and receive messages using satellites. Planes, ships, mobile medical units (warfare, ocean races, etc.) are important potential users of telemedicine services that can only operate using communications satellites.
- Flexibility: In the case of a natural disaster or even of a wire breaking, large data transmission and reception capability can very quickly be made available via space.
- Reliability: The reliability of a telemedicine system is a key element that cannot be jeopardized by the communications link.

5. Conclusion

All these assets can make a significant difference in the telemedicine market and represent the added value of space in this area. Nevertheless, the space industries have to evaluate their assets in this emerging market. Telecommunications companies foresee very important investments in this market for the next decade. New actors may appear interfacing between the medical fields, telecommunications suppliers and information technology.

For an efficient strategy, space has to work in cooperation with the medical sector to better understand the needs and the evolution of these needs. The telemedicine market will evolve quickly as the work methods of the

physicians will evolve. This cooperation will allow space industries to provide the telemedicine market with services fitting the users' needs.

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Government and Commercial Space: Communications Satellites

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Abstract

Since the October 1957 launch of Sputnik I, there has been only one truly commercial space industry: satellite communications. The market for communications satellites and launch vehicles has been a multi-billion dollar business for many years. Launch vehicle development has been dominated by governmental efforts. In contrast, the development of communications satellites has been primarily commercial. All of the governments of space faring nations have sponsored successful communications satellite technology programs. Not all have been commercially successful.

1. Overview of Development of Communications Satellite Market

The period from 1957 to 1996 during which communications satellites were launched can be divided - rather arbitrarily - into four periods of approximately ten years duration each: 1957-1967, 1968-1978, 1979-1987, and 1988-1996. While these periods are somewhat arbitrary, it will be interesting to examine the changes in operators, manufacturers, and launchers during these periods.

1.1 The First Period: US Dominance

From 1957 to 1967, 51 communications satellites were launched. All were operated by American organizations, manufactured by American companies, and launched on American rockets. Of these 51 satellites, 33 were military and 18 were civilian. NASA dominated the civilian launches either directly (Echo, Relay, Syncom, ATS) or indirectly (Telstar, Intelsat II). During this period, COMSAT was granted a civilian satellite communications monopoly in the United States, and Intelsat began to establish itself as the international civilian satellite communications monopolist.

1.2 The Second Period: The Rise of Intelsat and the Advent of Domestic Satellite Communications

From 1968 to 1978, 83 communications satellites were launched. American manufacturers (77) and American rockets (80) still dominated this period, but the operators became much more diverse. Military satellites were still most numerous (33), but international satellites (Intelsat and Inmarsat) were almost

as numerous (24). Domestic satellites (Domsats) were first launched during this period, for Canada (3), for the US (7), and for Indonesia (2). And, for the first time, Europe (5) and Japan (4) launched experimental communications satellites.

1.3 The Third Period: Domsats Dominate

From 1979 to 1987, 108 communications satellites were launched. American manufacturers (92) and American rockets (76) still dominated the industry, but European manufacturers (9) and especially the European Ariane rocket (24) were making inroads into this American dominance. Domsat operators (77) dominated this period, with military (25) and international (13) satellite operators definitely losing their previous importance. Many Domsats were American (30), but satellite communications truly became ubiquitous in this period.

1.4 The Fourth Period: The European Challenge and Crowded Skies

From 1988 to 1996, 172 communications satellites were launched. American manufacturers (122) still dominated this industry, but European manufacturers (39) were growing much stronger. For the first time, European launchers (93) dominated, with many other countries bringing their launch vehicles into the commercial market for the first time. Domsats and regional satellites (125) continued to dominate the industry, with European operators growing rapidly.

1.5 Politics, Economics, Technology, and Space Markets

In the sections below, the American, European and Japanese communications satellite programs are examined in more detail. For a variety of political, economic, and technological reasons, these programs had different degrees of success at different times. The United States, Japan, and many other countries have a tradition of being entrepreneurial. Most countries also have some tradition of government support, direction, and/or performance of innovation. This mix of entrepreneurial firms, large companies, and government, in different proportions, form the innovative systems of the United States, Japan, and Europe.

2. Government and the Communications Satellite Market in the USA

2.1 The First Period: 1957-1967

AT&T proceeded to design a MEO satellite and Hughes a GEO satellite. By 1960 AT&T was looking to buy launch services and Hughes was looking for a partner/customer. NASA rejected the AT&T request for launch services and told Hughes that they were only interested in MEO satellites. RCA apparently had no interest in "commercial" space, but they saw the military and NASA as a major customer for satellites of different types. RCA bid on the NASA program, eventually called Relay, and beat AT&T, Hughes, and Philco (among others) for the award (Reference 1). All four companies would eventually get communications satellite "contracts."

AT&T's Telstar was launched first, in July 1962. The NASA/RCA Relay was launched in December. The NASA/Hughes Syncom was launched in January, but suffered a failure during orbit-raising. A successful Syncom launch was made in mid-1963. The Delta rocket would be the main communications satellite launch vehicle for almost a quarter century.

If the technology for satellite communications had been proved by a combination of commercial and governmental efforts, politics made implementation a strictly governmental issue. AT&T had traditionally formed "partnerships" with national Post Telegraph and Telephone (PTT) organizations for trans-oceanic communications. These "partnerships" included some sharing of manufacturing and installation of facilities. As it became obvious that a government-sponsored organization, COMSAT, would be given a U.S. monopoly of satellite communications, the European PTTs became concerned that they would be squeezed out of the picture. Intelsat was formed to own and operate the global communications satellite system. COMSAT would have the U.S. monopoly, but the PTTs would retain their national monopolies and a proportional ownership of Intelsat.

After passage of the Communications Satellite Act of 1962, and especially after the formation of COMSAT in 1963, the U.S. Congress was unwilling to fund NASA research in communications satellites. By broadening its scope to "applications," NASA was able to continue communications satellite research under the aegis of the Applications Technology Satellite (ATS) program.

2.2 The Second Period: 1968-1978

Four trends are visible in the second period: (1) the continued importance of military satellites, (2) the rise of Intelsat, (3) the sudden increase of domestic communications satellites, and (4) the growing dominance of Hughes as the most successful manufacturer of communications satellites.

COMSAT and Intelsat evolved substantially during this period. In 1973 a formal arrangement entered into force under which COMSAT became the Intelsat Management Systems Contractor until February 1979. During this period, COMSAT/Intelsat launched 22 satellites (8 Intelsat III and 14 Intelsat IV/IVA). These 22 satellites dominated trans-oceanic communications and in the process made the world a smaller place. In addition, COMSAT, under contract to the U.S. Navy, launched three Marisat satellites which formed the basis for the International Maritime Satellite (Inmarsat) system. Of these 25 satellites, 17 were built by Hughes.

Of the 83 satellites launched between 1968 and 1978, 77 (93%) were manufactured in the U.S. and 80 (96%) were launched by American rockets. Of the 26 "domestic" satellites, 10 (38%) were launched for American operators. The ATS program came to an end with the launch of ATS-6 in 1974. Many observers, especially within the NASA community, felt that foreign experimentation would allow the U.S. to lose the satellite market.

2.3 The Third Period: 1979-1987

By the 1980s, military satellites and international satellites no longer dominated the market. Of 111 satellites launched during this period, 73 (66%) were "domestic," 30 (41%) of these were American domestic satellites used extensively for cable television program distribution. This period also saw the beginning of "commercial" space shuttle operations and the shutting down of the U.S. expendable launch vehicle (ELV) programs. The shuttle was not optimized for commercial communications satellite launches and market share was beginning to be lost to the European Ariane rocket. After the Challenger disaster in 1986, American ELVs were quickly brought to market and upgraded, but, as the next period would show, Ariane had already won the race for the market. Government intervention had neither created nor aided the ELV market, but rather contributed to market loss.

2.4 *The Fourth Period: 1988-1996*

During this period American dominance of satellite manufacturing continued, but the ageing American ELVs lost ground to Ariane. Of 172 satellites launched in this period, 122 (71%) were manufactured in the U.S., but only 59 (34%) were launched on American rockets. This period saw the re-emergence of NASA in the communications satellite arena with the launch of ACTS in 1993.

2.5 *Conclusion*

The manufacture, operation, and launching of communications satellites in the United Sates were affected in different ways by government actions. Both manufacture and operations started out independently of government. For political (and possibly anti-trust) reasons, the U.S. government intervened by taking control of development (NASA) in 1961 and taking control of operations (COMSAT) in 1962. Hughes, the most successful communications satellite manufacturer, began its efforts on Syncom using its own funds and having no significant government-funded space projects in-house. Government in the United States seems to have affected communications satellite outcomes, but government did not create this technology, neither did it create the market for the technology.

3. Government and the Communications Satellite Market in Europe

The development of satellite communications in Europe was essentially driven by government initiatives, both at the national level and within the framework of the international organizations. A complicating factor was the question of the users of the envisaged satellite system, namely the state-owned PTTs which acted as monopoly providers of all telecommunications services. The PTTs were hardly optimistic over the economic prospects of a European communications satellite system, compared with the existing terrestrial network.

3.1 *The First Period: 1957-1967*

Europe was a latecomer in the field of satellite communications. Only at the end of this period, in late 1966, was ESRO charged with studying an experimental satellite for telephony and television distribution in Europe and the Mediterranean area. At the same time, ELDO undertook to develop a rocket capable of launching small satellites into geostationary orbit, based on the *Europa* vehicle then under study.

Doubts existed about the economic aspects of the envisaged European telecommunications program. The organization of the European PTT administrations (CEPT) calculated that a satellite system for telephony, telex and data transmission within Europe would be more expensive than the conventional ground network and would not be competitive with the Intelsat system (References 2,3).

3.2 The Second Period: 1968-1978

It was within the framework of the newly established ESA that the European telecommunications satellite program finally came into being. Only the first phase of the program was approved, however, including a technology research program and the development of an experimental satellite, called OTS (Orbiting Test Satellite). It was successfully launched by a Delta rocket on 11 May 1978.

A decision on the second phase of the program, aimed at developing the operational European Communications Satellite (ECS), was to be taken by a qualified majority of participating countries at a later stage. CEPT stepped in, announcing its interest in studying a satellite system providing telephone and data transmission services, as well as television distribution for the EBU. A CEPT study of July 1971 showed, however, that the estimated operational costs of the envisaged ECS system would be far in excess of the savings in the terrestrial cable network. The PTT administrations made it clear that the development of the European space industry could not be financed by their customers. In other words, not only had the governments to provide for ESA's R&D program, but also to subsidize the procurement and operation of the ECS satellites (References 4,5).

3.3 The Third Period: 1979-1987

On Christmas Eve 1979, the *Ariane* rocket lifted off for its successful maiden flight from Kourou, in French Guiana. The newly created *Arianespace* company entered the competitive market of commercial satellite services which it would eventually dominate. The last qualification flight of Ariane, on 20 December 1981, put into orbit the first commercial communications satellite built in Europe, the maritime communications satellite MARECS A, whose communications capacity was to be leased to the Inmarsat organization.

After two years of complex negotiations, the end of all-European collaboration in satellite telecommunications was established. France and

Germany decided to undertake a joint project for developing two DBS satellites: the first, called TV-Sat, serving Germany, the second, called TDF, serving France. The other ESA member states undertook the joint project *Olympus* within the framework of the Agency's telecommunications program.

The first TV-Sat was launched in November 1987, but it had to be abandoned because of the failure of one of its solar panels to deploy. A second satellite was launched in August 1989. Two TDF satellites were successfully launched in October 1988 and July 1990. None of these satellites had a follow-on.

3.4 The Fourth Period: 1988-1996

Against all expectations, the biggest demand for EUTELSAT communications services was for television distribution rather than telephony and business data traffic. By the end of the 1980's the European DBS scene was dramatically changed by the first market-oriented undertaking: Astra (SES), a private company established in 1985 in Luxembourg. While government-supported development in DBS technology (Olympus and TV-Sat/TDF) had focused on high-powered systems (>200 Watt transponders), Astra was based on an American medium-power RCA satellite (45 Watt transponders). Advances in ground-based receiving technology made it possible to use small, cheap dishes both for cable distribution networks and direct-to-home services, making high-power DBS obsolete prior to its actual introduction. After complex negotiations with the French and German governments, on the one hand, and with Eutelsat, on the other, an agreement was finally reached that recognized SES's right to compete in an open market.

3.5 Conclusion

The communications satellite market began to develop in Europe in the early 1980s, when the market was dominated by U.S. manufacturers. When the first operational satellite, ECS-1, came into service in 1983, American industry had already supplied almost 150 operational satellites. European industry remains uncompetitive with American manufacturers (Reference 6). The main reasons for these difficulties have been identified in the fragmentation of the European market into small national entities, and ESA's industrial policy of geographical return. Guidelines for a reform of the Agency's industrial policy, to be implemented in the following two years, have been developed at the recent Ministerial Meeting of the ESA Council, on 4 March 1997. The stated aim is "optimizing the performance-to-cost ratio of the Agency's program,

improving the worldwide competitiveness of European industry, ensuring equitable participation by all Member States, and exploiting the advantages of free competitive bidding" (Reference 7).

4. Government and the Communications Satellite Market in Japan

Japan had recovered from the effects of World War II by 1957, but had neither the technology nor the funds to begin a space program. Nevertheless, Japan created a Space Science and Technology Preparation Office in 1960 and a National Space Development Center in 1964 (see Reference 8). This became the National Space Development Agency (NASDA) in 1969. NASDA is unique among space agencies in that (1) it is not a governmental agency like NASA, but rather a public corporation like COMSAT, and (2) it is strongly directed toward space applications and space technology rather than space science. Space science is the province of another organization, the Institute of Space and Astronautical Science (ISAS).

4.1 The Second Period: 1968-1978

Although Japan participated in Intelsat from its beginnings, and Nippon Electric Company (NEC) was a leading manufacturer of communications satellite Earth stations, satellite experiments did not begin until the late seventies. The communications (NTT), broadcast (NHK), and meteorological (JMA) agencies presented their requirements for satellites to NASDA; NASDA then formulated "research projects" to develop appropriate satellites. With the partial exception of the Engineering Test Satellites (ETS), all of these projects involved the pairing of a Japanese manufacturer with an American manufacturer. Mitsubishi Electric Company (MELCO) was paired with Ford Aerospace to build communications satellites (the CS program). NEC was paired with Hughes Aircraft Company to build weather satellites (the GMS program). General Electric was paired with Toshiba to build broadcast satellites (the BS program). The obvious intention was to maximize technology transfer and to create several indigenous satellite manufacturers. All three programs were generally successful; GMS-1 and CS-1 were launched in 1977 and BS-1 was launched in 1978. All three were launched on Delta launch vehicles. All three were essentially American-built.

4.2 The Third Period: 1979-1987

For most of this period the relationships among NASDA, the Japanese manufacturers, and the American manufacturers remained the same - with

perhaps a growing portion of the actual work being done by the Japanese companies. Nine satellites were launched, all sponsored by NASDA, and all on Japanese launch vehicles. In spite of the appearance of success, there were clearly problems. Two commercial non-governmental organizations were created to tap the potential of satellite communications: Japan Communications Satellite Company (JCSAT) and Satellite Communications Company (SCC). Both companies chose to buy American satellites and European launch services. SCC was a Mitsubishi company, part of the conglomerate which built the ETS and CS satellite series and built the N and H launch vehicles.

4.3 The Fourth Period: 1988-1996

During this period, 17 communications satellites were launched for Japanese operators, only five on Japanese launch vehicles, and only three were manufactured by Japanese companies. These three were all manufactured by MELCO: two had substantial contributions from Ford Aerospace and the third was experimental.

4.4 Conclusion

Japan has been successful in marketing satellite components and subsystems, and especially the marketing of Earth stations. Japanese launchers, specifically the H-2, will soon be offered at market rates - which are about half, or less, of their actual costs. It may be that Japanese satellites are also too expensive for the market. In any case, more than a quarter century of effort by one of the world's leaders in high-technology has resulted in no truly "commercial" sales of either satellites or launch vehicles.

5. General Conclusions

Communications satellites are a unique space market. This market was not created by government, although the enabling technology - rocketry - was. Satellites themselves were initially developed by industry in the United States, generally, but not exclusively, using internal funds. In Europe, massive government contributions were channeled via ESRO/ESA, with some countries, notably France and Germany, also funding important national programs. Government support was a key factor both for technological development and for creating the EUTELSAT market. This support was strictly linked with the essentially political goal of developing an independent launch capability. The remarkable commercial success of the private SES/Astra business, on the other hand, was based on American technology. In Japan, government funding helped

to transfer American technology to Japanese companies, but never resulted in commercial sales. The development of the communications satellite market suggests that governments are unlikely to develop new space markets. They may advance or retard these markets, but other forces will establish them.

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Report on Panel Discussion 5

Teleservices

This session was chaired by **H. Chasia,** Deputy Secretary General of ITU, who defined teleservices as providing services at a distance, including tele-medicine, tele-education, etc..

According to R. Brouard:

Knowledge is the most important economic resource. In the developing nations, satellite technology has the capacity to reach teachers in remote and educationally deficient areas and, hopefully, to improve teaching skills and productivity. The Venezuela project, a distance learning program to train teachers because so many teachers are teaching without a degree, was described. This project was financed by a World Bank loan of 1.2 billion dollars and Galaxy Latin America offered one year of satellite time, free. Some barriers arose, such as communications infrastructure, rural/urban disparities, education leadership and vision. He concluded that this concept can be applied to other countries, basically in the areas of tele-education and tele-medicine, and he recommended public/private partnerships.

According to P. Lee:

Tele-medicine was defined as the use of telecommunications and computer technologies with medical expertise to facilitate remote health care delivery, and its goal is to provide higher quality health care at a lower cost. Tele-medicine can be especially useful in remote areas, to transfer medical information, and to provide medical education and support during emergencies. He presented several barriers, both technical and non-technical, to the expansion of tele-medicine. More attention should be paid to non-technical barriers, such as lack of experience, confidence, awareness, and legal and regulatory issues. The technical barriers are likely to be solved with increasing bandwidth, new compression techniques, faster switching, and LEO systems. He predicts a big potential market for tele-medicine in ten years time.

According to L. Valignon:

Tele-medicine is a new way to deliver health care and can provide quicker and more accurate diagnoses. He presented several legal and economical

obstacles which have to be solved before tele-medicine can become a commercial market. The space added-value on the tele-medicine market comes from manned space mission experiences and from space telecommunications assets such as worldwide cover, mobility, flexibility and reliability. There is an urgent need for the space industry to strengthen its involvement in tele-medicine.

According to D. Whalen, represented by R. Williamson:

The only real commercial market in space is satellite communications. A comparison of the development of the telecommunications market in the US, Europe and Japan was presented. He concluded that it is not unreasonable to argue that market forces have dominated, yet government investments in commercially oriented space markets are no guarantee of positive contributions to the economy.

Session 6

Markets for 2020?

Session Chair:

P. Diamandis, X-Prize Foundation, USA

The X PRIZE Competition

Peter H. Diamandis, President, The X PRIZE Foundation, St. Louis, Missouri, USA

1. What Is The X Prize?

The X PRIZE is an international competition for the practical demonstration of the first reusable craft capable of taking three people to the edge of space (100 km, or 62 miles) and back. The X PRIZE is modeled after the great aviation prizes of the 1920's and 1930's. A particular example is the Orteig Prize of $25,000 which resulted in Charles Lindbergh's landmark flight from New York to Paris in 1927. This flight transformed aviation from the category of "stunts" to the beginnings of the multi-billion dollar aviation industry which has linked the world.

The X PRIZE Foundation is a nonprofit educational foundation created for the purpose of developing the prize and educating the public about the benefits of public spaceflight. Since its inception two years ago, the X PRIZE has obtained the endorsement and support of numerous organizations and individuals, including NASA, the Lindbergh Family, the Explorers Club, The Association of Space Explorers (the world membership of Astronauts and Cosmonauts), and many other groups.

Because of the positive vision portrayed by the X PRIZE Foundation and its historical parallel to Lindbergh's flight, the St. Louis community has provided the X PRIZE with approximately $1 million in startup funding. The X PRIZE Foundation, headquartered at the St. Louis Science Center, is working to raise $10 million. The Foundation is working to implement both the X PRIZE Competition and its education program.

2. Why Was the X PRIZE Created?

No one today doubts the social and economic benefits that have resulted from the aviation industry which knits our planet together. Yet, within the memory of many, aviation was considered a foolhardy activity, suitable only for scientists and daredevils. A series of prizes served as catalysts which dramatically altered public perceptions of aviation. Today, we are on the threshold of a similar change in perception about commercial spaceflight, beginning with the use of near-Earth space for rapid suborbital flight between locations on our planet's surface. It is our belief that the X PRIZE can catalyze a

set of technological and perceptual changes which will result in future benefits of equal magnitude to those of our present aviation industry.

Many have examined the "chicken and egg" problem of human access to space. It is widely believed that, once a reasonable traffic flow is established (today there are less than 30 commercial launches per year), the cost of space access will decrease dramatically in response to pent up demand. A recent survey project undertaken in Japan indicates that the market for space tourism alone exceeds $5 billion annually. The key issue remains "what is the first step towards public access to space?" The X PRIZE provides this vital first step by creating the incentive for the creation of the vehicles needed to address the space tourism market.

Professor Freeman Dyson, of the Institute for Advanced Study in Princeton, long an advocate of public spaceflight, suggests that what is needed is a fundamental change in the "style" of space operations. Others have observed that all present space vehicles are built upon the heritage of expendable munitions (converted ICBMs) rather than the transportation vehicles which are common today on land, sea and air. If changing the style of spaceflight seems to be an unusual way to obtain the result of public access to space, consider the change of style in electronic computing which took place between the 1940's and the 1970's. In 1943, Thomas Watson of IBM was quoted as saying that the world market for computers was 5 machines, worldwide. Though an extreme statement, the notion that computers were tools only accessible to governments, large universities and research organizations prevailed until Jobs, Wozniak and other personal computing pioneers harnessed the demand for individual computing to drive an innovation cycle which doubles the performance of computers roughly every 18 months.

The X PRIZE is designed as a catalyst to challenge the international aviation and space communities to demonstrate innovation. The time-honored tradition of the great aviation prizes of the 20th century transformed commercial aviation - Lindbergh's successful flight had a profound effect upon the way people viewed aviation. Similarly, the X PRIZE will both change the style of space operations and foster the development of the first vehicles to break the world out of the "chicken and egg" dilemma regarding public access to space.

3. Public Benefits of the X PRIZE

There will be substantial benefits to be gained from the technologies and events resulting from the X PRIZE. These benefits can be categorized as follows:

- Rapid Transportation
    - Cargo transport
    - Passenger transport
- Access to Space
    - Telecommunications advances
    - Access to space resources
- Philosophical/Motivational Benefits
    - A change in personal worldview
    - Public motivation and a new generation of heroes
    - Promoting education

Cargo transport. Just as air mail was one of the first applications of commercial flight, the rapid transport of high value packages will be one of the immediate applications of commercial suborbital flight. The spectacular success of the worldwide air cargo industry and overnight delivery services such as Federal Express, in particular, underscore the world need for rapid delivery of high value packages. Such services have proved to be especially important for the movement of human blood and blood products, organs for transplant, medicines, drugs and high value electronic components. In addition, the ability to deliver emergency supplies or equipment to literally any point on the Earth within 45 minutes, will have a dramatic impact on emergency relief and other humanitarian efforts.

Passenger transport. The ability to transport people between any two cities on Earth within one hour is likely to have an impact even greater than that caused by the low cost jet transport revolution of the 1960's. The ability for people of average means to experience world travel directly has changed the nature of international relations and increased human understanding. Those who originally believed that air travel would always be intrinsically more expensive than surface travel were wrong. In addition to reducing costs, rapid air travel also permitted people who could not otherwise afford the extended time away from their occupations a chance to make trips within a reasonable time period and experience the world firsthand. Similarly, rapid

suborbital flight will create a second wave of personal connectivity as barriers to first hand contact are removed. In the future, a business person in New York can undertake a meeting in Tokyo with the same time allocation that a meeting in St. Louis might require today. If this seems somewhat far-fetched, just image how today's busy travel schedules might have appeared to the observer in 1927 when Lindbergh made his flight.

Most of the fuel expended by commercial flights today is used to overcome the drag caused by the atmosphere. The renowned aircraft designer, Burt Rutan (developer of the Voyager aircraft which performed the first nonstop flight around the world), has suggested that suborbital flight will be more energy efficient and environmentally benign than present day technologies.

In summary, rapid, suborbital point-to-point access will link our world physically, giving us nearly instantaneous physical connectivity, in much the same way that the Internet links us electronically today.

Telecommunications Advances. Among the practical benefits resulting from the creation of low-cost access to space is the enhancement of global telecommunications, particularly for developing nations. At present, the high costs of space launches continue to keep satellite-based communication as a tool of the relatively rich. (Launch costs account for 50% of a satellite system's capital expense.) Low orbit constellations currently under development promise to provide space communications to developing nations - but at a premium price. Lowering the launch cost will enable the development of numerous satellite systems and therefore competition on a truly global basis.

Access to space resources. Nearly a century before the Club of Rome published Limits to Growth, Konstantine Eduardovich Tsiolkovsky identified the resources of space as a practical solution to many of the foreseeable problems of energy, environment and population pressure on our planet. Low-cost power via solar power satellites, or lunar derived helium 3, as well as extraterrestrial (lunar and asteroidal) materials represent resources of tremendous value to the human race. Yet, 36 years after Yuri Gagarin's first orbital spaceflight (on 12 April 1961), access to space remains expensive, exotic and an activity that is almost synonymous with governments.

A change in personal worldview. The philosophical benefits to the public resulting from space tourism are immediate, widespread and historically observable. Human spaceflight has had a profound and positive impact upon society. As Buckminster Fuller predicted, the sight of the Earth as

seen from lunar distance altered for ever our view of the world and our species' role in its protection. The famous Apollo 8 image of the Earth from space is considered one of the most familiar photographs in the world today. Amazingly, this impact has been the result of vicarious experience. Studies of the approximately 400 astronauts and cosmonauts who have had first hand experience of space travel indicate that an even more profound and beneficial change takes place in their worldview as the direct result of their experience. Imagine the benefit as today's world leaders, and captains of industry, begin to take advantage of this new transportation service and obtain, as an additional advantage, an expanded personal worldview.

Public motivation and a new generation of heroes. An immediate public gain resulting from the X PRIZE is the creation of a new generation of public heroes. Children and young adults around the world will recognize and strive to emulate this new generation of X PRIZE heroes who embody intelligence, innovation, vision and courage. As the result of his 1927 flight, Charles Lindbergh became the first worldwide hero, a role model, and an inspiration to literally billions of people.

Promoting education. A more lasting benefit relates to education. Our experience as educators has shown that space is a powerful tool for motivating students. People respond very strongly to activities which provide hope for themselves, for society and for the environment as a whole. Key components of the X PRIZE expanded education and outreach program are directed at students. But the benefits from educating the public about their opportunity personally to travel to the space frontier are not limited to traditional students. The general public will profit as well.

Frederick Turner's frontier thesis put forward the notion that the psyche of America was directly shaped by our frontier experience. America's position as a land of opportunity stemmed in large part from the perceived need for people to participate in the settling of our expanding physical world. More recently, other writers have amplified on Turner's thesis. No longer is it fashionable (as it was in the late 1960's) to discredit the impact of the frontier, or the lack thereof, on the well being of our nation, from both a physical and psychological view. The general public has a deep and ongoing interest in both the history of the pioneering of aviation and space frontiers as well as considerable interest in what the future will bring. Indeed the most visited museum in the United States is the National Air and Space Museum, in Washington, D.C.

4. The X Prize Competition

4.1 Recent X Prize Activities

Registration procedures have been defined and published, along with Guidelines for the X PRIZE Competition, announced on 18 May, 1996, in St. Louis. Fifteen teams from three continents have already officially registered to compete. The X PRIZE trophy was designed and selected via a competition. The trophy was constructed and unveiled in St. Louis, and now is on display at the St. Louis Science Center.

Regarding education, an Xploration Gallery and astronaut exhibition have already been created at St. Louis Science Center. MIT and at least six other Universities have agreed to compete in an "academic" X PRIZE Design competition at the undergraduate and graduate level. This competition with a cash award for the winning school, will culminate in May/June 1998.

4.2 X PRIZE Mission Statement.

The mission of the X PRIZE Foundation is to create a future in which the general public will personally participate in space travel and its benefits. The foundation seeks to do this by:

- Organizing and implementing competitions to accelerate the development of low-cost spaceships for travel, tourism and commerce.
- Creating programs which allow the public to understand the benefits of low-cost space travel.
- Providing the public with the opportunity to experience the adventure of space travel directly.

4.3 The X PRIZE Creed

We believe that spaceflight should be open to all - not just an elite cadre of government employees or the ultra-rich. We believe that commercial forces will bring spaceflight into a publicly affordable range. We will use our best efforts to achieve this goal.

We believe that the resources of space are the key to enhancing the wealth of all nations and people while preserving and repairing the environment of our home planet. We believe that this is our duty to our species and our fellow passengers on spaceship Earth.

We believe that the risks involved in human spaceflight are far outweighed by the benefits to the participant and to humanity. We will use our utmost efforts to foster safety for participants, observers and the public in all X PRIZE activities.

As we work towards our goal, we will conduct ourselves as individuals and as an organization in accord with the highest standards of fairness, honesty and respect for our partners and the public.

4.4 Education Project Description

To maximize the educational value of the excitement being generated by the X PRIZE Competition, we intend to expand our outreach and education program. This expanded program has two principal components, both of which are extensions of present pilot activities.

The first major thrust involves giving students and the general public the opportunity to meet and learn from the astronauts who have flown in space. The second element involves giving the general public a chance to experience spaceflight themselves through a range of physical and virtual exhibits. These programs are designed to dovetail with, and be supported by, the ongoing X PRIZE Competition and awards programs.

The specific objectives of these two programs include:

- To reach over 4 million people over the course of two years.
- To test a number of different methodologies of outreach to the general public, to determine which is the most effective.
- To collect survey data from over 200,000 people for the purpose of tailoring our message, measuring the effectiveness of our education program, and understanding the public's interest in space and space tourism.
- To maximize the educational value of the immense media attention which will result from the X PRIZE Competition once the teams begin launching.
- To convey to students and the general public:

the impact which X vehicle technology will have for cargo and passenger transport in the future,

the fact that they will personally have the opportunity someday to explore the space frontier,

an understanding of the direct benefits of public spaceflight to themselves and to society,

an appreciation for the new generation of heroes participating in opening the space frontier and

a sense of excitement and hope for a positive future.

Program #1: Astronaut outreach - Sharing the epic journey. There is a small group of people (about 400 persons strong at the time of this writing) who have gone into space as the emissaries of the human race. These are humanity's astronauts and cosmonauts. Their stories and adventures are an amazing example of bravery, vision, perseverance and intelligence - all attributes to which we aspire, and which we hope to teach our children.

We are, by nature, a species which learns through the telling and retelling of epic stories. Our inquiries indicate that the public is hungry for and ready to learn from the messages which present day space travelers can convey.

Theater - Space "Off Broadway". Astronaut Mike Mullane (who has flown three Space Shuttle Missions) and his wife Donna Mullane have created a one act play, 75 minutes in length, which communicates the excitement and beauty of fulfilling a lifelong dream of flying in space while also sharing the fears and anxiety of both the astronaut and his family. Together they have given their performances to audiences across the U.S. - reaching 250,000 people over the past five years. Their message is one of family, hard work and vision. The recent success of the film Apollo 13 was due in large part to the recounting of the entire story (including both the personal and technical aspects) of that epic Apollo voyage. The strong response of the public to Apollo 13 and to the pilot Mullane's presentations indicates that this "personal connection" is of great value in conveying the broader story. Thus far Astronaut Mullane's show has only been available as a private showing, typically organized for special events, conferences, and corporations. The X PRIZE plans to produce a version of the play suitable for students and the general public in a theatrical format, for general public audiences.

Operationally, our objective is to develop a financially self-sustaining set of performances which use theater to convey our educational messages, to a broad audience, in a memorable and personal setting.

Program #2: Exhibits. The second major element of our proposal is an outreach program to the attendees of the 1997 Oshkosh annual convention and air show of the Experimental Aircraft Association (EAA). In concert with the St. Louis Science Center, we are planning an exhibit at Oshkosh which is the world's largest aerospace event. In addition to presenting the X PRIZE and our vision of the future, this exhibit, which will also feature St. Louis' history and future in aerospace, will be seen by the leaders and the elite of the aviation and space communities.

In March, 1997, the X PRIZE Foundation received the endorsement of the Experimental Aircraft Association. The EAA is the largest aviation public interest group in the world, with over 160,000 members. Its annual convention, held for the last 25 years at Whitman Field in Oshkosh, Wisconsin, attracts over 800,000 persons annually. In addition to endorsing the X PRIZE, EAA President Thomas Poberezny offered to provide the X PRIZE Foundation with prominent exhibit space at the entrance to the convention site. He also agreed to publish articles in the Association's magazine in the month prior to the convention and to give the Foundation a platform from which to address the convention at two of the large public forums during the week-long exhibition.

This offer provides the X PRIZE Foundation and the St. Louis Science Center with an outstanding opportunity to reach several hundred thousand of the most active members of the aviation and aerospace community. In addition, the exhibit under development for Oshkosh is being designed from its inception for use in other future traveling exhibitions and science center sites. At the conclusion of the Oshkosh event, we intend to use the exhibit materials to enhance our Xploration Gallery display at the St. Louis Science Center significantly. As of June, 1997, the Science Center will host the headquarters of the X PRIZE Foundation and we are eager to use this opportunity to improve and expand our home base exhibit.

5. Conclusion

The X PRIZE is committed to opening up the space tourism industry through the use of competitive prizes and related educational programs. Since the announcement of the X PRIZE in May 1996 in St. Louis, the amount of media attention and support from the space-related community has been outstanding. The management and Trustees of the Foundation feel that the registration of the 16 teams (as of May 1996) represents a validation of the concept that

privately financed, suborbital space tourism vehicles will soon be barnstorming around the world.

The X PRIZE seeks to encourage the participation of as many participants from around the world in this competition, and in the Foundation's educational programs, as possible.

Facilitating a New Space Market Through a Lunar Economic Development Authority

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Abstract

The creation of space economic development authorities (SEDA) present a near-term, viable strategy for the use of space resources. This is a legal and financial mechanism to encourage private investment in the formation of both a space infrastructure and offworld commercial opportunities, as well as promote scientific research on the high frontier. If the 21st Century is to realize the industrialization and settlement of space, humanity must establish innovative governance, management and funding systems which move beyond sole support from public taxes and operations only by national space agencies. An attitude change is necessary for space to become a place for the practice of synergy, so that planners promote global cooperation in human enterprises aloft, especially through public-private partnerships in space macroprojects.

Specifially, to return to the Moon permanently, utilize its resources, and facilitate both economic activity and settlement there, the prototype SEDA program will be the founding of a Lunar Economic Development Authority (LEDA). The next step would be feasibility studies on applying this model to form a Mars Economic Development Authority (MEDA) and then an Orbital Economic Development Authority (OEDA). Such legal entities would provide a means for international collaboration and support of new space markets, while fostering private sector participation and investment. For LEDA to become a model in this process, legislation and agreements might enable it to:

- Issue bonds to underwrite lunar enterprises, such as a transportation system, industrial parks/bases, and projects ranging from beaming solar energy toward Earth to mining helium 3;
- Coordinate and facilitate international endeavors on or near the Moon by space agencies, scientific organizations, universities, and private corporations or consortia;
- Create a leasing system and site permits for activity on or underneath the lunar surface, so as to build facilities, habitats and other infrastructure;
- Provide an overall administration and security for lunar settlements and installations, as well as for commercial operations and tourism;
- Protect the lunar environment and ecology, possibly through regulations, zoning or inspection.

The whole SEDA goal is to further private initiatives and entrepreneurs on the space frontier, so as to advance the creation of a spacefaring civilization for the new millennium.

1. Introduction

Expanding human enterprise on the space frontier during the 21st Century will require both attitudinal change on the part of planners and entrepreneurs, as well as new synergistic relationships and institutions. Gump (Reference 1) maintains that we are entering a new era of free enterprise aloft that will create an orbital economy. To open and develop new space markets also calls for

people who are enterprising, that is, ready to engage in financial and technological ventures with imagination and initiative. To succeed in such endeavors demands strategic planning and management. Criswell (Reference 2) comments:

"By 2050, lunar power industries can be sufficiently experienced and profitable to diversify into a wide range of other products and locations, other than solar power beaming. Specialized industries on asteroids and other moons will arise. Mankind can begin the transition to living independently off Earth. People can afford to move to space and return the womb of the biosphere Earth to the evolution of other life."

Attitudinal change implies that space market leaders explore funding prospects that go beyond the traditional public contracts and tax support. A cogent case for investment in space enterprises will attract new capital and participation by world corporations, venture capitalists, and individual financiers. Such a synergy (Reference 3) is vital for space endeavors which are very complex, costly and involve high risk with people, technology and finances. The private sector should be more involved in formulating and setting space policy, particularly with regard to establishing relative priorities as to joint undertakings on this frontier. Global collaboration in space undertakings is demanded by the world marketplace, as well as by current economic constraints on national space budgets. International space cooperation is necessary not only among nations and their space agencies, but between public and private sectors, as well as among universities, research institutions, corporations and non-profit associations.

The cultivation of emerging space markets calls for public-private partnerships (Reference 4):

"Partnering is a long-term commitment between two or more organizations for the purpose of achieving specific business objectives by maximizing the effectiveness of each other's resources."

Sometimes this occurs by forming a strategic alliance or consortium. Once such contemporary example in the Asia-Pacific launch vehicle business (Reference 5) is Sea Launch. Established in 1995, this public-private partnership involves participation by the United States, Russia and Europe (Boeing Commercial Space, RSC Energia, KB Yuzhnoye and PO Yuzhmash, and Kvaerner). Synergistic partnering or alliance is essential for companies and

industries, especially for small businesses and start-up firms (see Space Entrepreneurs Association[1]).

2. Commercial, Legal and Political Challenges in Lunar Enterprise

Among the multiple markets aloft, we focus on the lunar venue. To realize the Moon's potential, there are hurdles to overcome and mechanisms to be put in place. Since 1967, the exploration and use of outer space has been the exclusive province of nations and their designated space agencies. Furthermore, international space treaties under the United Nations have not been pro-business development; individual citizens are not able to leave Earth and engage in offworld commerce unless licensed by their governments. Investors currently have little incentives to underwrite lunar enterprises - treaties preclude private ownership, transportation costs to and from the Moon are excessive, governments do not provide tax advantages for lunar expenditures, and the return on investment appears to be decades away (Reference 6).

The problem with all these schemes is that they are fragmented - humanity lacks a common strategy, no less a global institutional mechanism for developing the Moon's resources and markets. One proposal called for a UN International Space Centre to use extraterrestrial resources better. But as we approach the end of the 20th Century, no agreement yet exists on an entity to coordinate and facilitate such efforts and markets offworld. Yet there is a growing consensus within the space community on the need for such a global institution (Reference 7).

Representatives of various disciplines continue to press for lunar enterprise. For example, the University of Wisconsin's Fusion Technology Institute advocates He^3 as a potential billion dollar isotope market. Colorado State University's Center for Engineering Infrastructure and Sciences in Space promotes inflatable shelters covered with lunar regolith as the product of the future; others push programs on the lunar surface for extracting oxygen, water, aluminum, iron and even glass. But living and working safely and profitably on the Moon requires multidisplinary, multi-institutional, and multinational mechanisms to be in place if such proposals are to be implemented (Reference 8).

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[1] For information of the Space Entrepreneurs Association, contact David Anderman at the Space Frontier Foundation (E-mail: DavidA5625@aol.com), or USIS Regent, Michael Simon at International Space Enterprises (4909 Murphy Canyon Rd., Ste.220 , San Diego, CA 92123, USA; E-M=Michael@isecorp.com). For electronic exchange on SEA, contact Jim Benson (E-M: scia@Space Dev.Com).

3. Space Economic Development Authorities

To resolve this impasse and further human enterprise in space, the United Societies in Space, Inc. (USIS) and its affiliated World-Space Bar Association (W-SBA) have devised a strategy for immediate implementation.[2] Called the Space Economic and Development Authority (SEDA), the concept is to form a series of such authorities for both public and private international participation, aimed specifically at providing the financing, governance and management for free enterprise development of space resources and settlement.

There is signifcant legal precedent and history on the creation of quasi-public legal, as well as private, authorities and trusts to further infrastructure development on this planet. This is a respected, proven and traditional approach to underwriting and managing both public and private undertakings, or a combination thereof, across jurisdictions and borders. Such authorities have been used worldwide to construct major projects from airports, bridges and tunnels, to toll roads, power grids and convention centers.

Spaceport authorities have been established in various states of the USA, to provide launch facilities and related services which improve the economic viability of the region where located. One example is the California Spaceport Authority (Reference 9) which manifests entrepreneurial innovation to take advantage of the launch facilities of the U.S. Vandenberg Air Force Base and nearby USAF bases. CSA was authorized to further the development of commercial launch, manufacturing, academic and research operations, as well as to receive Federal grants for these purposes.

A three-stage development plan of SEDA calls for the formation of three separate and specific space authorities during the first half of the 21st Century. The first is the protoype Lunar Economic Development Authority (LEDA). Next is the formation of a Mars Economic Development Authority (MEDA) to encourage science, commerce and settlement on the Red Planet. The third is an Orbital Economic Development Authority (OEDA), conceived for long-term construction of orbiting colonies (Reference 10).

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[2] Non-profit organization, United Societies in Space, Inc. and the World-Space Bar Association are headquartered in Denver, Colorado, USA (3300 East 14th Street). Together they publish twice a year the journal, *Space Governance*, and conduct an annual space governance conference the first weekend of August. For further information, telephone 1-800/895-META; fax: 1-303/721-1182; E-Mail: USISpace@aol.com; Internet homepage: http://www.USIS.org). Currently, USIS has branches in Russia and Mexico.

4. Lunar Economic Development Authority

Perhaps the possibilities of such space authorities can be appreciated best if we examine LEDA in some depth. As we have made clear in previous articles, we see it as the first demonstration model (Reference 11). Space lawyer colleagues who have examined the plan have commented (Reference 12):

"The Lunar Economic Development Authority, similarly, will be structured to create an international regime that would encourage, as well as regulate (rationalize) the habitation of and commerce on the Moon. The LEDA fills in blanks of an incomplete space law with details that can make space available for human development in a very short time."

"The USIS Lunar Economic Development Authority (LEDA) proposal is a serious step in the right direction. It is important that this proposal be viewed as being in accordance with international space law. The Outer Space Treaty which has been ratified by over 90 nations is particularly important. Few states, or their commercial entities, would seriously consider participating in a venture which was not perceived as being in accordance with The Outer Space Treaty.... LEDA comports with the key principals of international law."

We examine two key questions related to this strategy.

4.1 How Will LEDA Facilitate New Lunar Markets?

Financing new ventures. If properly constituted, a Lunar Economic Development Authority would be in a position to issue bonds for public sale that would provide a new funding source for lunar enterprises, beyond the allocation of tax monies. It remains to be seen whether these bonds would or would not have government guarantees behind them. Of course, national legislative bodies , such as the U.S. Congress, might also create tax incentives for investors in these bonds, such as extra exemptions (e.g., double or even triple deductions). These new funds might be used to contract in the global private sector for a reliable, low-cost lunar transportation system, not only to/from the Moon, but on/under the lunar surface itself. LEDA would also underwrite the construction of a *lunar infrastructure* from a base to an industrial park, with all the suitable habitation and commercial facilities required. When such basic provisions are in place, LEDA then might be able to offer grants to universities, research institutes, corporations, and consortia that wish to undertake scientific, industrial and educational programs on the Moon or beneath its

surface. These progjects might range from astronomical observatories to start-up ventures related to lunar mining, solar energy and even tourism.

Attracting venture capitalists and investors. If a legal mechanism such as LEDA were in place, it could finance media efforts to show the value of providing capital and investment in lunar enterprises. LEDA would act as a magnet to draw venture capitalists, financiers and entrepreneurs to subsidize and engage in emerging lunar markets. Such activities for living and working on the Moon might extend from clothing, equipment and food systems necessary to survive and improve the quality of life in a low gravity environment, through the production of lunar oxygen and water, to building lunar ports for launching to Mars, the asteroids and other planets.

Providing a legal regime for the lunar venue. Assuming that LEDA is brought into being as a result of international agreement, individuals and corporations might be willing to invest time, talent, energy and money in technological ventures on or off the Moon, if a leasing system were in place. Thus, developers could theoretically obtain a 99 year lease to build a factory, high tech park or settlement. The fees paid for such service could be placed back into LEDA administration, so that it would be a self-supporting means of governance. In time, LEDA might offer zoning, regulatory and inspection services to further orderly developments, while protecting the lunar environment and ecology.

Coordinating global efforts on the Moon and its vicinity. LEDA could have the capability of facilitating human enterprise in the use of lunar resources, encouraging international cooperation, while avoiding overlap among various national space agencies, corporations and organizations. LEDA could not only foster science and commerce on the Moon, but create a strategic and holistic lunar development plan.

Eventually, lunar dwellers could take over the administration of LEDA, and shape it to suit their own unique environment and needs. Earthkind and spacekind in the human species will discover a growing interdependence, so that governance principles of space societies will provide for home rule (Reference 13).

4.2 How Will LEDA be Legally Constituted?

Our current research indicates four potential ways for formulating a prototype Lunar Economic Development Authority.

National legislation. One country could assume the leadership to establish LEDA, and then invite other national partners to join in the venture. That is what happened with the present International Space Station when NASA eventually entered into agreements with other national participants. In this scenario, for example, the United States of America might pass an Act of Congress to formulate LEDA unilaterally. Some assets of NASA, the Department of Defense, or the U.S. Air Force might be transferred to the new Authority for the creation of a terrestrial lunar launch port (e.g., turning over a military or space base for this purpose). Those assets could then be used to back a bond issue.

International consortium. A group of spacefaring nations and/or organizations which are interested in lunar development might enter into an international agreement they would allow or authorize LEDA to act on their collective behalves in financing and macro-managing resources on or about the Moon. INTELSAT is precedent for such an action, when some 28 nations signed an agreement through their designated public or private telecommunications entitites to form this worldwide, telecommunications satellite system. Although space is for the benefit of humankind, member states may own shares and share in the profits of this enterprise. In fact, the organizational structure of INTELSAT today, as it changes and becomes more commercially oriented, might apply to LEDA.

Private transnational enterprise. A group of profit and/or non-profit entities might act synergistically to incorporate LEDA in one or more States. Under that "umbrella", they might combined their assets and plans for lunar development, and engage in joint ventures on or about the Moon. Many terrestrial macroprojects have been legally accomplished by free enterprise, with or without the participation of government.

Space metanation. A new "nation" in space, sponsored as a commonwealth of terrestrial nations (Reference 14), could develop. Ideally, this meta-nation should come into being for the 21st Century under the United Nations charter which has a provision for a Trusteeship Council of New Territories. Under this scenario, the spacefaring nations might become the trustees for the next hundred years of a space metanation which has the power for self-governance, including the establishment of appropriate economic development authorities, starting with LEDA. Should any space authorities be inaugurated before metanation, that body could assume administration of them.

5. Conclusions

To open and nurture vigorous space markets for the next century requires a new impetus, as well as a new appreciation of existing space law. We have suggested a general strategy to accomplish both, called a Space Economic Development Authority, beginning with a prototype, Lunar Economic Development Authority. This approach is consistent with existing space law and treaties that preclude appropriation of space resources by any one nation or entity. It is also compatible with the agreed principle that space be reserved for the benefit of humanity. In our proposal, an international agreement entered into on a reciprocal, voluntary basis would permit LEDA to engage in rational lunar activities for the benefit of both Earth's inhabitants and our interplanetary commons, beginning with the Earth-Moon system. LEDA is an international regime for the orderly and safe development of natural resources on the Moon, and their effective management for the expansion of opportunities by their use. There is ample legal precedent for innovators to craft this mechanism for a stable legal environment that will promote both scientific and commerical use of lunar resources.

Referemces

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Extraterrestrial Resource Exploitation

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Abstract

To date, the only resources that humankind has exploited have been those of the Earth. Although historically these have been treated as though they are inexhaustible, this is not the case. Without new resources, humankind will be unable to develop technologically or extend significantly its activities into the solar system. It seems likely, therefore, that extraterrestrial resources will have to be identified and made use of. Not only would these be fresh sources of existing material needs, but also completely new types of resources. Examples of such extraterrestrial resources are: space-based solar generation of power returned to Earth by microwave beam; extraction of lunar helium-3 for use in future terrestrial fusion power sources; and mining of the near-Earth asteroids. The future utilisation of extraterrestrial resources offers a means to provide significant benefits for humankind. Although the development and utilisation of such resources exceeds our current abilities, it is envisaged that the increasing importance of such resources to the terrestrial (and later solar) economy will drive the development of the technological capabilities that are needed.

This paper presents an overview of the different types of extraterrestrial resource utilisation and examines the possible future market for, and benefits of, each of them. In addition, the associated economic, political and legal issues relating to extraterrestrial resource exploitation are discussed, while the technological developments required to bring them to fruition are also examined.

1. Introduction

The suggestion that extraterrestrial resources be utilised is not a new one. It dates back almost one hundred years to the pioneer Konstantin Tsiolkovsky (Reference 1) who anticipated human beings building space colonies, using solar energy for terrestrial and space-related purposes, colonising and utilising asteroids and planets and eventually expanding into the cosmos. In 1929, the physicist Bernal (Reference 2) discussed the need for the use of extraterrestrial resources and proposed the use of asteroidal materials for the construction of large spacecraft. In the middle and early second half of this century, Clarke (Reference 3) and others continued to promulgate the concept. It was not until the 1970s, however, that the idea became more widely known through O'Neill's book *The High Frontier* (Reference 4). Focusing on the use of lunar materials for the construction of space colonies and solar power satellites to supply power for the Earth, this caused NASA to produce two studies in the field (References 5 and 6). Since this time work in the field has continued, the most recent being reported in *Resources of Near-Earth Space* (Reference 7) and Lewis' very readable popular work *Mining the Sky* (Reference 8).

2. Global Modelling

Linking in to the visionary works described in the previous section has been parallel work in global modelling, examining the interactions between population, resources, consumption and pollution. The most famous was the Club of Rome work, *The Limits To Growth* (Reference 9), which concluded that population growth and resource overconsumption would lead to a collapse of civilisation in the 21st century. Later studies drew similar conclusions. However, these studies viewed the Earth as a closed system with finite resources. Other studies have examined the effect of the introduction of extraterrestrial resources into the global models. Using the same model as the *Limits to Growth,* Martin (Reference 10) demonstrated that, with the removal of constraints on resources and technology development, the effects of the growth in human activity could also be removed. Schultz (Reference 11) extended Martin's work to show that a number of space-related investment strategies exist by which it should be possible to reverse the decline predicted for the 21st century. These results are of interest in the search for new markets inasmuch as, if civilisation collapses, the marketplace (as we currently understand it) will cease to be.

3. Terrestrial Resource Needs

Although global modelling is obviously a limited tool, it is a useful technique for exploring the medium-term future. However, not all commentators see the future as bleak, as can be seen when considering terrestrial resources needs, particularly energy.

3.1 Energy

From 1950 to 1995 the total world energy consumption (TWEC) rose from ~ 1.0 x 1020 $J.yr^{-1}$ to 3.9 x 1020 $J.yr^{-1}$. According to IOE97 (Reference 12), TWEC will rise by around 60% between 1995 and 2015 (to 5.9 x 1020 $J.yr^{-1}$), due mainly to increasing energy use in Asia, Eastern Europe and the former Soviet Union. Almost 90% of the TWEC is expected to be met by fossil fuel sources. Kulcinksi (Reference 13) predicts that the world per capita energy use (PCEU) will increase by 10% of its current level (7.6 x 1010 $J.yr^{-1}$) by 2020 and by 35% by 2050. To obtain the TWEC, this increase in PCEU is multiplied by world population which is predicted to rise by around 60% to just over 9 billion people by 2050 (Reference 14) before levelling off at around 10 billion by 2100 (Reference 15). (This forecast runs contrary to the Limits To Growth predictions which give a monotonic decline from 2030 as a result of falling natural resources).

Consequently, the TWEC in 2050 is predicted to be 120-150 % greater than the current level. Based on these figures, a total energy need for the 21st century of around 6.1×10^{22} J may be identified. Of this need, about 70% may be provided by fossil fuels stocks, with consequent environmental effects. Should concern over these effects come to the fore, or should fossil fuels be considered more valuable as feedstock for manufacturing processes, markets for new, less polluting, forms of energy generation will arise. In any event, the remaining 30% of the energy need will have to be generated from other sources which will also offer new market opportunities.

3.2 *Minerals*

Minerals are very important to the global economy. The total world mineral commodity exports in 1990 were valued at about $\$2 \times 10^{12}$ (Reference 16). Factors controlling mineral availability are a complex function of geology, technology and economics. Existing reserves are fairly well-defined. However, unlike energy, minerals tend to have very specific uses and applications, and are not readily interchangeable so factors controlling demand are difficult to assess. Assuming that future consumption will be at least equal to present consumption (Reference 17), and probably several times larger, it appears that for certain minerals (e.g. thallium, sulphur, mercury, lead and zinc) there are currently around 10-20 years of reserves left. For others (e.g. cobalt, tungsten, nickel) the figure is between 50 and 100 years. At the moment it seems likely that within the next century the world will run short of these minerals, thus creating a possible market for these from other sources.

4. Extraterrestrial Resource Needs

Future extraterrestrial resource needs are substantially more difficult to quantify than terrestrial ones since they will depend entirely on developments in the exploration and use of space. Many of the resources that will be needed are those that are already required for current activities such as sustaining life, generating power and propulsion. These include food and water, oxygen and hydrogen, and solar photovoltaics. Whether these are most economically supplied from Earth or from extraterrestrial sources depends upon the space infrastructure and, importantly, on the cost of delivering payload into orbit.

If access to space is expensive and there is little activity in space, it will be cheaper to provide all resources from the Earth. Alternatively, Parkinson (Reference 18) has derived a model characterising a well-developed space economy in which the bulk of the extraterrestrial material needs are met

from extraterrestrial sources. It is apparent that there is a considerable amount of bootstrapping possible in space development. The more activity in space, the more economical it becomes to support it using extraterrestrial resources. However, the initial effort required to develop such capability will not be forthcoming unless it offers clear and direct benefit to the inhabitants of Earth, i.e. there is a market for the resource and it can be produced in such a way as to make a profit. The most marketable resources will be those that offer the quickest benefit to the Earth.

5. Extraterrestrial Resources

What, then, are the extraterrestrial resources that may be useable and/or marketable in the future? These may be grouped in terms of their location.

5.1 Space

Solar energy. The solar flux at the Earth is ~1350 $W.m^{-2}$. Orbiting satellites could collect this power, convert it into electricity and return it to Earth by microwaves. This is called the Solar Power Satellite (SPS) concept and was first proposed by Glaser in 1968 (Reference 19) and later popularised by O'Neill (Reference 4). Each satellite would operate in geostationary orbit and transmit its power to a receiving station on the ground. The baseline configuration featured a satellite of area of 50 km^2 and a ground-based rectenna of 75 km^2 to produce 5 GW. A substantial amount of work was done on the SPS concept in the USA in the 1970s before the idea fell out of favour. Recently, however, there has been a resurgence of interest (Reference 20) and work on a LEO-based SPS system has been performed in Japan (Reference 21).

Studies (Reference 22) indicate that SPS costs lie over a range, the lower end of which is broadly comparable with existing energy generation systems and the upper end of which would preclude economic development. As always, the launch cost to LEO is identified as a key factor which, in this case, must be less than 75 $\$_{1995}.kg^{-1}$ (Reference 23). Most (90%+) of the materials required for SPS could be obtained from the Moon. This would reduce the number of launches from Earth, but would require substantial lunar/space infrastructure instead (Reference 24).

5.2 The Moon

Solar energy. As well as Earth-orbiting SPS systems, the idea of collecting solar energy for transmission to Earth using Moon-based collectors, the Lunar Solar Power System (LSPS), has also been suggested (Reference 25). LSPS has advantages over SPS in that it would be easier to site and build. However, it would also be in the dark half of the time during the 14 day lunar night and would also require orbiting microwave reflectors around the Earth and Moon and multiple receiving stations on the Earth. The construction and operation of the LSPS would require many hundreds of thousands of tonnes to be launched from both the Earth and the Moon each year, making low launch costs even more important than for SPS. The cost of a 20,000 GW system has been calculated as $\$_{1995}$ 22 x 10^{12} over 30 years. This seems very large, but is of the same order as would have to be spent on terrestrial sources to obtain the same energy.

Oxygen. Oxygen is by far the most abundant element on the Moon, constituting 42% of the lunar soil. Extracting this oxygen would be particularly attractive since it would provide a breathable atmosphere for humans and could also be used with hydrogen in fuel cells. Possibly more importantly, however, is its use as a propellant. Around 85% of propellant mass in cryogenic propulsion systems is liquid oxygen and the propellant mass makes the bulk of the initial spacecraft mass. If propellant for return trips from the Moon could be manufactured in-situ, then Earth-Moon transportation would become substantially cheaper. It might also be economical to deliver lunar oxygen to LEO rather than lift it from Earth. The processes by which oxygen may be extracted can be classified into three types; chemical, electrolytic and pyrolitic and substantial work has been done on these (Reference 7). Sherwood and Woodcock (Reference 26) have evaluated the costs and benefits of lunar oxygen production and are guardedly optimistic about the economic return, while making the point that, overall, a wider and more integrated capability is more likely to provide benefits than one focussed on a single product. They also identify technical problems that will need to be solved which include various aspects of handling lunar regolith and the means by which permanent facilities can be placed on the lunar surface.

Volatiles. Over geological time the solar wind impacting the lunar surface has implanted the elements hydrogen (96%) and helium (4%) in the surface, plus traces of nitrogen, carbon, krypton, xenon and argon. Because of impacts, these are to be found to depths of several metres. They can be released by crushing and heating the regolith (particularly ilmenite). Hydrogen is of

interest since it can be used as a propellant and to provide water; a number of schemes for releasing it have been proposed (Reference 27). The others may all have a role in future lunar industry. Helium is of special interest, however.

Helium-3. ^{3}He, an isotope of helium, is significant because of its possible role (when used with deuterium) as fuel in future fusion power plants to generate electricity. ^{3}He is very rare on Earth and extraction would not be economic. Kulcinski et al. (Reference 28) have noted that ^{3}He is present, however, in extractable quantities in the lunar regolith and suggest this as a source for terrestrial reactors. Sved et al. (Reference 29) have suggested that mining an area of regolith of just over 3 km^2 to a depth of 3 m would return some 50 kg of ^{3}He, enough to power a 500 MW fusion plant for one year. They report that the recoverable reserve of ^{3}He may lie between 0.7 and 1 x 10^6 tonnes. They project that one quarter of the global electricity supply in 2050 could be provided by lunar ^{3}He and suggest that this is achievable through taking a flexible approach to finance and a 'pay back as you go' approach to return on investment. The technological developments required to bring this venture to fruition are split equally between those required to develop fusion power plants, particularly those of the Inertial Electrostatic Confinement type, and those required to develop mining and refinement processes which will work successfully on the Moon.

Non-Volatiles. Waldron (Reference 30) suggests that production of aluminium, magnesium, iron, titanium and calcium feedstocks and alloys should be possible, as well as a variety of crystalline and glassy materials which could be used as abrasives, insulators, dielectrics, electrodes, as well as cements and glass structures. Waldron anticipates that solar photovoltaics could be manufactured, but are unlikely to be an early priority. It is doubtful that any of these would find a market on Earth, but would have a significant market on the Moon and in space unless Earth to LEO launch cost was extremely low. Waldron cites Woodcock (Reference 31) as having determined that the lunar economic value of non-volatile products would probably exceed that of lunar propellants.

Water. There is some evidence from the Clementine mission that there may be water trapped at the poles of the Moon. This may have arrived via cometary or asteroid impacts and then remained in permanently-shadowed cold traps. If this is the case, it is likely to alter radically the concepts and plans for lunar colonization and resource exploitation since it will make activities on, and travel to and from, the Moon substantially easier to support.

5.3 Near-Earth Asteroids

Near-Earth Asteroids (NEAs) are objects with orbits that cross or graze the Earth's orbit. They vary in size from about 10 to 40 km in diameter and around 200 have been observed (but more certainly exist). Access to many NEAs is comparatively easy in terms of energy with round trips being easier to them than to the Moon, albeit with longer trip times (this is even more true for the Martian moons, Phobos and Deimos).

Volatiles. It is deduced that about half the NEAs are made up of carbon- and water-rich chondritic materials, thus making them very attractive for resource exploitation (Reference 32). Typical volatile products which might be obtainable from NEAs include compounds of hydrogen, oxygen, sulphur and nitrogen (including water). In addition, propellants, organic compounds and hydrocarbons may also be produced from them. All of these are likely to have markets in future space activities, as long as they can be obtained economically.

Metals. The remaining half of the NEAs consists mostly of S-type (stony) bodies with a much smaller number of M-type (metallic iron) asteroids. Overall, these will contain some 20% of metallic iron-nickel alloy with a small amount of cobalt, and small traces of rare and valuable metals and non-metals (Reference 33). The high-value metals, such as platinum, may be returned to Earth, while the much greater quantities of ferrous materials could be used in space, perhaps for SPS construction.

6. Economic and Legal Issues

Exploitation of extraterrestrial resources is not an end itself, but rather a way to bring benefits, whether in the form of energy or return on investment. There is little doubt that the exploitation of extraterrestrial resources will involve an investment of many billions of dollars and is likely to find success only if economically justifiable. One way to offset this cost would be if space industrialisation commenced with comparatively modest and specialised products which then led on to larger scale activity, a point made very clearly by Woodcock (Reference 34). In the case of the viability of lunar ^{3}He extraction, this is acknowledged by Schmitt (Reference 35) where an early business objective would be the sales of non-power technology applications related to fusion development. Such approaches would help demonstrate returns on space investments that are otherwise deferred considerably and, at least from the current perspective, very risky. It is likely that joint government-industry partnerships that allowed the private sector to secure the

benefit of its efforts would be the most effective way to developing new markets for extraterrestrial resources. This can be achieved by having government act as 'anchor tenant' for commercial undertakings. A change of attitude of the private sector to space is also required, from merely selling things to use in space to using space and its resources to make money. This shift has ocurred as far as the use of satellites is concerned, but has yet to develop in any other areas. Additionally, throughout the economic analyses of space industrialisation, the necessity for a substantial reduction in the cost per kilogram to LEO is emphasised repeatedly.

Meanwhile, the international legal position of extraterrestrial resource exploitation is confused. The 1967 Outer Space Treaty (Reference 36) is the fundamental charter of international space law. This makes no specific reference to resource exploitation though Article 1 does mention use which might be deemed to include this. It also prohibits national appropriation by any means, but not appropriation by other bodies or individuals. Since ratification the UN has ruled that outer space including the Moon and other celestial bodies does not include the resources found on them. In 1979 the Moon Treaty (Reference 37) was opened for signature by the UN. Article 11 of this declares extraterrestrial resources to be the common heritage of all mankind and requires all parties to it to establish an international regime ... to govern the exploitation of the natural resources of the Moon which shall ensure an equitable sharing ... in the benefits derived from those resources. Although this treaty achieves the desires of the developing nations, it has not been ratified by a number of countries including the USA, China, Japan and the former Soviet Union. Although, to date, this has not been a matter of great concern, since no resources have yet been exploited, this is unlikely to be the case in the future. Consequently, the supporters of lunar ^{3}He exploitation have addressed the problem through their proposed INTERLUNE organisation (Reference 35). This is modelled on the INTELSAT and INMARSAT agreements, recognises the common heritage concept, and seeks to provide an equitable and acceptable means of developing this resource while providing a competitive return on investments.

7. Conclusions

The area in which extraterrestrial resources could have the biggest market lies in the provision of environmentally clean energy, either through solar power satellite systems or through the use of lunar helium-3 in fusion reactors. It is unlikely that significant amounts of extraterrestrial material resources, other than specific high-value precious/strategic metals, will be returned to

Earth in medium-term future. However, extraterrestrial resources from the Moon and near-Earth asteroids will have a very important role to play in supporting the development of the space infrastructure necessary for any meaningful level of space industrialisation. Such industrialisation will only commence, though, when clear and direct benefit from it is apparent. For this, several things are necessary. First, the cost of placing payloads into LEO must be substantially reduced. Secondly, a programme of resource assessment involving robotic exploration of the Moon and near-Earth asteroids must be performed to clarify our understanding of the resource base. Thirdly, new mechanisms and policies for government and commerce partnerships must be established which provide appropriate rewards for both. Fourthly, the uncertainties in current space law must be addressed, either through a new treaty or through structures that seek to obviate these. Only once these have been achieved will the exploitation of extraterrestrial resources be able to commence in a meaningful manner.

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International Market for a Reusable Launch Vehicle[1]

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Abstract
A reusable launch vehicle (RLV) could be developed early next century if the X33 program is successful. Only its development will be funded by the industry, with the vehicle being operated privately. Thus a critical task is to assess the future market for such a vehicle. The total number of commercial payloads could be around 40 to 60 satellites per year, taking into account the market elasticity due to the launch price reduction. The RLV would face important competition from expendable launch vehicles. However, it could capture two thirds of this market, or 26 to 43 commercial payloads per year.

1. Introduction

Since the first launch of an artificial satellite in 1957, much technological progress has been accomplished by the aerospace industry. However, expendable rockets are still the most effective way to place a payload into orbit. The technology of expendable launch vehicles (ELVs) is now well known and mastered; however, these vehicles are still insufficiently reliable and expensive to operate, even if the competition between different launch vehicles is growing. A truly reusable launch vehicle (RLV), with reduced ground operation cost is believed to be able to reduce the launch cost by an order of magnitude. The Space Shuttle example should not prevent any research toward this objective. Several programs have been launched to develop a new, fully reusable launch vehicle. The most important is the X 33 program. A single-stage-to-orbit (SSTO) rocket propelled vehicle should be developed early next century, if the demonstrator program is successful. The development phase should be funded mainly by industry, with the vehicle being operated on a fully private basis. This approach represents a very serious financial challenge, to be added to the technological one. So a critical task is to assess the future market for such a vehicle.

2. Satellite Market Forecast

The operational vehicle should enter commercial use by 2005 at the earliest. The prediction of the launch market ten years in advance is a very difficult exercise as accurate data are rare. This paper presents a synthesis of different studies. Probably the most comprehensive one is the "Commercial

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Space Transportation Study" (CSTS, 1994) conducted by the Alliance of the major American aerospace companies (Boeing, General Dynamics, Lockheed, Martin Marietta, McDonnell Douglas and Rockwell) and NASA between June 1993 and February 1994. The European consulting group Euroconsult also published an important study in 1994: "World Space Markets Survey - 10 Year Outlook" (EC, 1994), and, more recently, an evaluation of the launch market from 1996 to 2010 (EC, 1996)

The different segments of the satellite market of interest for a future commercial RLV are the telecommunication segment (which can be subdivided into Fixed Satellite Services - FSS, Mobile Satellite Services -MSS, Direct Broadcast Services - DBS, and Broad Band Services - BBS), the Global Positioning System (GPS) segment, remote sensing satellites, and potential new markets.

2.1 Fixed Satellite Service (FSS)

FSS covers the transmission of analog or digital data over long distance through geosynchroneous satellites from one fixed point on Earth to another. The first application is long distance telephone transmission. This application currently represents less than 20 % of the traffic on FSS, due to heavy competition from fibre optic cables on the ground. However, the satellite remains attractive as it permanently covers a continent-size area and it has the flexibility to shift capacity between ground stations. Satellites can be used to restore the service from a lost cable. International businesses show a growing interest in transmission of data from/to their remote units. Oil industries, car manufacturers, department stores, etc., use Very Small Aperture Terminals (VSATs) to link their different locations and exchange computer data like inventories or book keeping, or perform video conferences. This demand now accounts for more than 10% of the FSS traffic. The third segment of FSS is the television industry. The broadcasting networks use satellites to transmit signals from remote locations to a central production facility and from a central production facility to affiliates or cable operator head ends. This represents more than 60 % of the capacity of the FSS.

During the early 1990s, the demand for telecommunications satellites has sharply increased. The number of transponders in the C and Ku bands for commercial use went from 1812 by the end of 1987 up to 3341 in early 1994, or an average growth of 9 % per year. 15 FSS satellites have been launched in 1995 and 20 in 1996. This high launch rate is due to the need for Intelsat to replace ageing Intelsat V satellites and a booming demand in the Asian region.

However, the recent studies forecast a reduced number of launches after 2000, to around ten FSS satellites per year. Then the number of launches should increase again up to 20 satellites per year in 2004 - 2005 according to the CSTS (1994) study. This represents the most probable scenario. The demand should go up to 24 to 27 satellites per year in the period 2005 - 2010.

These estimates are based on the current launch price of the expendable rockets. The future RLV should be marketed at a significantly lower launch price. The CSTS study presents a model of price elasticity. The cable programmers (the predominant users of FSS) commented that the gain in bandwidth due to digital compression is not used to reduce the size (and hence the price) of the satellite, but to provide additional capability while maintaining the current budget for satellite usage. As in the current situation the cost of the launch is roughly equal to the cost of the satellite; a reduction 50% in the launch cost reduces the system cost (satellite plus launch) by 25%, inducing a 25% percent increase in the number of launches for a constant total cost to the operators.

2.2 Direct Broadcasting Service

The satellite is used to broadcast television and radio programs directly to homes, using powerful amplifiers on board the satellite and small (thus inexpensive) receiving antennas on the ground. The digital compression, allowing allowing the transmission of up to 8 channels on a single transponder, reduces the cost of broadcasting and stimulates the market. New private projects are launched on all continents almost each day. Digital radio is an emerging market with, for example, projects like WorldSpace which will deploy three satellites to broadcast more than 100 radio channels over Third World countries. This market segment does not require as many satellites as the FSS market: one spacecraft is servicing a large area and the transmission is only one way. The different studies forecast an average of four to seven satellites per year, at the current price, for the period 2005 - 2010.

2.3 The Mobile Satellite Service

The mobile services provide wireless communications from/to any point on the globe (except the polar regions). The current systems use geosynchronous satellites: Inmarsat provides communications to ships, aircraft and land mobile on the whole planet. Private operators like the American Mobile Satellite Company provide cellular telephone services on a regional level (USA and Canada) also using GEO satellites. The competition in the wireless telephone

service moves now toward using constellations of small satellites in LEO or Medium Earth Orbit (MEO). Iridium and Globalstar, ICO and Ellipso are the most advanced in each category. The LEO systems are using 42 to 66 satellites of 500 to 700 kg to be launched in different planes in order to assure a full coverage of the Earth (or most of it) at any time. The MEO systems need 12 satellites weighting 1950 kg (ICO). The deployment of the constellations are planned for 1997 to 2000. The long term success of these new businesses is not yet secured. Most experts believe that only one LEO and one MEO system can succeed. The competition from the ground network is very intense in Europe, Japan and heavily populated areas of North America. The systems are aiming at the developing countries and areas of low density population. The RLV will enter the launch market when the satellite constellations will need to be replaced. The expected life time is 5/7 years in LEO and 10 years in MEO. The LEO constellation will need a big number of launches around 2005 - 2007 and the MEO around 2010. The market will represent about 20 to 27 satellites per year in LEO, to be launched ten at a time by the RLV. If the launch cost were lowered to $ 2000/kg, the market could move up to 33 to 48 satellites per year, or 3 to 5 packages per year.

2.4 Broadband Telecommunications

A different system has been proposed to address the future needs of global connection between computers by building a world-wide wireless network with high capacity: Teledesic is fully focused on serving computers. It would use 300 to 400 satellites in LEO, using a large bandwidth in the Ka-band to cover the whole planet. It has been proposed to the G7 summit as a contribution to the infrastructure of developing countries. Sativod, a less expensive constellation is proposed by Alcatel, using 40 satellites. The deployment of such new broadband services is planned after 2000. The RLV would be used for the maintenance or the replacement of those constellations. The potential market is about 10 satellites (or one RLV launch per year) in a high probability case (where only the Sativod class constellation is viable) to 100 satellites or 10 launches a year in a medium probability case (if Teledesic is successful).

Global Positioning Service

The Global Positioning System (GPS) is a very good example of a space system application that is spreading into the everyday life of almost everybody. Initially deployed for the sole use for defence of the USA, it is now used for a multitude of civil applications: positioning of ships, aircraft, spacecraft, trucks, mapping for geospatial information systems, etc. New

applications are proposed each day. Systems to aid car navigation are being developed in the USA, Europe and Japan by automobile manufacturers and traffic authorities. The Federal Aviation Administration is moving toward allowing GPS as the sole means of navigation for aircraft. The European Eurocontrol authority is developing a complement to GPS (differential GPS) to allow non precision approach and later precision approach to be conducted with the GPS system. Similar programs are underway in the USA and Japan.

The service is actually provided by 24 satellites orbiting at 20 200 km altitude. The new generation (Navstar Block 2R) is deployed in 1996/97, with an expected life of 10 years, by the US Department of Defense. One can imagine that the system will have to be replaced as the number of applications is growing and some very important ones, such as aircraft navigation, could essentially rely on the GPS. If the emergence of a civil operated system is not obvious today (the development price is estimated at several billion dollars), a high probability assumption is the maintenance of the constellation. This market results in an average of 2.4 launches per year, assuming a 10 year lifetime for the satellite. A more aggressive option is to consider a constellation of 30 satellites, which is adding redundancy to the system. This would result in an average of 3 launches per year.

2.5 Remote Sensing

Earth observation was the second satellite application to emerge, after telecommunications. It has not yet developed into a commercial market of the size of the telecommunications market. The space segment is still provided by government developed systems (Landsat, SPOT, ERS, Radarsat, JERS, IRS) and the planned systems in future years are still in the majority of cases based on government funding. However, some fully private systems are proposed by US companies to enter the market of high resolution images with small satellites.

CSTS (1994) forecasts a demand of eight to ten remote sensing satellites for the period 2000 - 2010. The commercial market should represent three to five satellites. The mass of those satellites should not exceed 1000 kg in LEO. Thus, those satellites are not well adapted to the attributes of the RLV. They would probably require a single manifest launch due to their particular Sun-synchronous orbit. A RLV would not be competitive in this category with a small launcher like LMLV1 or an evolved version of Pegasus. Thus the potential market of commercial remote sensing applications is negligible for the future RLV.

2.6 New Markets

Today, the launch market relies only on telecommunications satellites, governmental missions and some remote sensing satellites. By the year 2005, some new commercial markets may have emerged.

Microgravity manufacturing is an emerging activity nowadays. In fact the microgravity activities are at the experimental level. All attempts at manufacturing commercial products in space have not been successful and the efforts have shifted toward R&D. A better understanding of the effects of microgravity on crystal growth, molecule development, living organisms, etc., is needed before undertaking large scale production in space. Moreover, the very high cost of the missions limits the application to very particular cases having strong advantages over the much less expensive ground processing. Incentives are given by governments to help the development of those activities. However the number of flights remains very low except for the governmental missions. The business plan of a future RLV should not rely on the development of commercial flights for microgravity applications. Those missions are already included in the governmental missions and flights to the International Space Station.

Some other markets could take advantage of a reduction in launch costs to become feasible. The first could be fast package delivery. A need exists for rapid delivery (few hours) from one continent to another. An example is high technology parts used in manufacturing plants. If a critical part fails, the company is willing to pay an extra shipping cost to get a spare and limit the time when the plant is not producing. This could be an important market: it could also create another one for products which where previously unable to travel due to their perishable nature. However, this market does not require a system to go into orbit, a suborbital flight is sufficient. A high operational flexibility of the vehicle is needed, along with a high availability and dependability. The customer will expect a delivery on time each time. The characteristics required for this vehicle are quite different from the requirements for the RLV, and therefore a less expensive, small launcher would better fit this market niche.

Another frequently mentioned market is that of hazardous waste disposal. The long half life nuclear waste produced by nuclear power plants could be sent into space (lunar dark side, or toward the Sun) instead of being stored

underground. Storing this waste on the Moon would eliminate the danger of very long duration storage on Earth, while not exposing the Moon to a significantly higher level of radiation than due to cosmic radiation, and still having the waste accessible if later they are found to be useful. However, this option requires several conditions to be feasible. The launch cost must drop below $1300/kg. Moreover, the launch vehicle must have an unreliability lower than 10^{-6} to have the risk of contamination at launch equivalent to that of burying. Then, the political obstacle must be worked out: is it correct to use the Moon for such a business according to the International Outer Space Treaty ? Will public opinion and environmental groups accept frequent launches of vehicles full of nuclear waste ? Who is controlling the process? If all the political and technical issues (ground processing of waste, lunar transfer vehicle and launch safety level) are successfully addressed, the potential market is estimated at about 100 000 tonnes of waste waiting to be processed. It would represent from 400 launches with a high capacity round trip lunar cargo to over 900 with a smaller one-way lander (expendable) (CSTS,1994). A rate of 25 flights per year could be assumed.

The last potential market could be space tourism. Many studies have concluded that some public interest exists to support space tourism. An important market could develop if certain criteria are met. The transportation cost must drop to a few hundred dollars per pound, and the launch vehicle must be dependable and reliable (same order as commercial aircraft, around 10^{-6}). However, the actual plan for the RLV does not take into account the requirements of those missions (a passenger cabin, a trajectory with a lower acceleration, etc.). So this market should not be included in the business plan of the future RLV.

None of these new markets have a sufficient prospect to be taken into account in the business plan of the future RLV. However, at least two of them (space tourism and waste disposal) could potentially generate a large number of flights each year if the launch cost were to be as low as $1200 per kg.

2.7 Summary

The worldwide (except Russia) commercial market for the RLV could range from 30 to 47 payloads per year at the current launch cost. Table 1 describes the price elasticity for each category. Those numbers represent the projected market for the period 2005 - 2010. As no serious data are available after this period,

the market will be assumed to keep a steady state during the entire commercial life of the RLV.

	High probability		Medium Probability	
Payload / year	@ current cost	@ $2000/kg	@ current cost	@ $2000/kg
GEO	28	35	34	54
LEO package	3	5	13	20

Table 1. Total commercial market

3. Potential Market Share of the RLV

The RLV will have to face strong competition from non US expendable launchers. The American expendable rockets (at least Delta and Atlas) should not be used any more for the governmental payloads; they should be phased out, as their main customer is the US government. So all the American payloads, should be launched by the RLV, according to the NASA assumptions.

Most European payloads will probably still be launched by European launchers. The ESA policy is to use Ariane for all European spacecraft. However, the commercial operators of telecommunications satellites will be private operators in the majority. Private operators are making business decisions essentially on the basis of the best economic proposition. If the RLV offers the best price, it will capture most of the market. However, it is important for these operators to have a multiple source of launch providers. If a technical problem forces the RLV to be grounded for several months, the operators still want to be able to replace their satellites, or expand their businesses. So Ariane 5, the Russian and the Chinese launch vehicles should still have a part of the launch market of private operators and international organisations.

Taking into account the severely competitive environment and some customers' preferences, the RLV would capture around two-thirds of the total commercial satellites market. The launch price with the RLV could be $4000/kg, as the expendable launcher should charge about $5000/kg by 2005. It is then possible to interpolate the market, taking into account the price elasticity from the current price of $11 000/kg, as shown in Table 2.

	High probability		
Payload / year	@ $11000/kg	@ $4000/kg	@ $2000/kg
GEO	19	23	35
LEO packages	2	3	4

Table 2. Number of commercial satellites to be launched by the RLV

4. Conclusions

The total number of commercial payloads could be around 40 to 60 satellites per year, taking into account the market elasticity due to the launch price reduction. The RLV would face important competition from expendable launch vehicles. However, it could capture two thirds of this market if offering a price of $4000/kg or less, which would be three times less than the actual western launchers' price. The RLV market in this case would consist of 26 to 43 commercial payloads per year.

Finally, some new markets could emerge if the launch cost is reduced enough - below $1200/kg. The future RLV operator would have to promote those new applications (space tourism, nuclear waste disposal, etc.). If a significant number of customers can afford to pay between $2000/kg and $4000/kg to assure a sufficient revenue, the operator could encourage those applications with promotional fares, sold at the marginal cost and not the average cost. It would be the only way to break the actual "chicken and egg" dilemma that those applications and inexpensive launch vehicles are facing. If technological progress allows a RLV having low operational cost to be built, then the opportunity to offer "discounts" for those new applications should not be missed.

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Report on Panel Discussion 6

Markets for 2020?

Panel Discussion:

There are 15 companies, from 3 continents, which are planning to participate in the X-Prize Competition, and there have been 35 requests for registration packets so far. The idea of the foundation is to attract entrepreneurs. The funding will come from advertising rights and high profile companies will be targeted. The first attempt is expected to take place in 2000 or 2001. Space tourism, satellite launching and package delivery are expected spin-offs from this competition . The space tourism market is expected to evolve from parabolic flights to sub-ortibal flights, and eventually to orbital flights.

There is concern about the damage to radio astronomers caused by microwaves transmitted to Earth for the purpose of transmitting solar energy. Basically, a trade off will have to be made. What is more important - solar energy or radio astronomy? Environmentally clean solar energy, that is gathered in space and transmitted down to Earth is still a dream for the future, but becoming increasingly more important as our terrestrial resources are becoming more and more scarce. Future acts of bringing minerals and rare metals back to Earth will be very costly and require an enormous amount of propulsion. To deal with this, it has been suggested to use the Moon as an operating base. It is important to start thinking about solutions to the problems that will be encountered now.

Keynote Address

New Space Markets, Eternal Human Needs

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1. What is New ?

Humankind has always looked to the heavens. This is understandable. After all, the sky itself is the fundamental timekeeper, giving us day and night. Our Sun saturates us with light, heat and energy. At the end of the day, darkness settles upon the land, but the heavens become fantastic: the moon with its sensuous glow – ever constant, ever changing – dominates the sky. Glittering stars seemingly take on the aspect of animate creatures as they dance from horizon to horizon. Is it any wonder ancient peoples believed that their gods dwelled among the stars?

Even after astronomers punctured the sweet old myths about space, accurately depicting it as a harshly inhuman environment, the heavens continued to stand as a symbol for noble aspirations.

We have had the great good fortune to be alive when humankind finally realized the dream of venturing into space. And what a realization it has been! Look at the record of the past forty years: We have sent men and women into space and even to the Moon. We have used unmanned craft to explore our solar system and beyond. We have placed a uniquely powerful telescope into space. We have created eyes in the sky for the betterment of human life. And, hovering far above the Equator, we have established a vast array of communications satellites. I believe that our achievements in space truly dignify the longing which has infused human souls for thousands of years.

I feel deeply privileged to be a keynote speaker at the Annual Symposium of the International Space University. This institution carries forward the finest traditions of our efforts to reach the heavens. The discipline and scholarship so evident here pay homage to the men and women whose courage, tenacity and brilliance has taken us into space. The charter of the International Space University reflects the desire of people everywhere to reach for the heavens. The founders of this institution – Dr. Peter Diamandis, Todd Hawley and Robert Richards – are visionaries. They created the ISU in 1987 when we

were enmeshed in the Cold War. Admittedly, the conflict between the superpowers did much to propel us into space. But it did so in the name of nationalism and fear. At a time when the world was divided by rivalry, ISU's founders clearly understood the unifying force of cooperation. This gathering celebrates the fulfillment of their vision. Today, professionals and students from six continents work together under the ISU banner to bring the benefits of space to all the people of the world.

Bringing benefits to people is what markets are all about... That brings us to the theme of this symposium: New Space Markets. Comprehending space markets is a straightforward matter. When we venture into space to create a product or service, the result is space market. Our theme becomes more challenging when we take it as a whole: new space markets. What is new?

This symposium consists of nine sessions; each session provides answers. Every participant at this ISU conference knows the short list:

- Innovative remote sensing applications
- Original arrangements between government and industry
- Futuristic possibilities for manufacturing
- Creative approaches to telecommunications
- And - yes - an unprecedented electronic medium... which, not incidentally, is being created by a company called WorldSpace.

But are these really new space markets? And we return to the nagging question: what is new? The dictionary defines the word ënewí as an adjective to describe something ìhaving been made or come into being only a short time ago.î A more intriguing thought on this subject is found in the Book of Ecclesiastes, a short philosophical essay in the Old Testament. Ecclesiastes contains profound insights conveyed in beautiful language. It begins with the well known words:

> *"Vanity of vanities, saith the Preacher, vanity of vanities; all is vanity. What profit hath a man of all his labor which he taketh under the Sun? One generation passeth away, and another generation cometh, but the Earth abideth for ever. The Sun also ariseth."*

Here, let us note the author of Ecclesiastes did not live to collect royalties from Ernest Hemingway. The next three verses contrast the mightiness of time and nature with the weakness of man, leading the author to observe:

"The thing that hath been, it is that which shall be; and that which is done is that which shall be done: and there is no new thing under the Sun."

There is no new thing under the Sun... I know what many of you must be thinking... and I share your sentiments. Wouldn't it be grand if we could revive the author of Ecclesiastes and take him to Paris! There we would show him cars and computers, and demonstrate telephones, television and Minitel. We would hop on the Metro, transfer to the RER and go to the Charles de Gaulle Airport for a look at some jets. After marveling at aircraft, we would go back into Paris to show him videos of spacecraft at the offices of Arianespace. And then we could ask him whether he thought there was anything new "under the Sun".

How could we not feel pride in the attainments – the new things – of our era? But there is a depth to this ancient wisdom which we cannot dismiss, a logic that cannot be denied. Look at every great achievement in statesmanship, commerce, the arts, the sciences. Examine every technological innovation. Do this. I defy you to identify a single major achievement that exists like an island, isolated from all prior experience. Sir Isaac Newton – one of the greatest original thinkers in history – acknowledged this truth when he wrote:

"If I have seen further it is by standing on the shoulders of giants."

If the author of Ecclesiastes is correct – if there truly is "no new thing under the Sun" – then what can we say about "new space markets?" I believe our common work in space markets represents nothing less than employing technology's newest achievements to meet humankind's oldest needs.

2. The Vision of WorldSpace

That is our approach at WorldSpace. We will use an innovative system to reach markets which, in effect, have been around for thousands of years. WorldSpace is serving as the catalyst for the creation of a new medium. The defining aspects of the medium are:

- It is global. A radio broadcaster anywhere on Earth can reach four fifths of Earthís inhabitants.
- It provides quality audio signals. Sound on the WorldSpace system will be far, far superior to short wave radio. No fading. No noise. No co-channel interference.

- It is abundant. The number of broadcast channels is so great that we will be able to create information affluence for even people in the most remote corners of the world.
- It is flexible. This medium offers the capacity to mix still images and data transfers with audio at very low cost... and doing so in a way that has no precedent: directly from geostationary satellites to personal, portable receivers. Unlike PC-based Internet systems, this technology will be accessible to people with no formal education... even individuals who are pre-literate.

WorldSpace is playing the central role in catalyzing this new medium:

- WorldSpace has brought together top engineers to develop proprietary technology.
- WorldSpace has assembled a team of engineering and scientific partners to create the software and build the hardware for this medium. Alcatel Espace is the prime contractor for our space segment. Matra Marconi is building the satellite bus for our three craft. Arianespace will launch our satellites. The first launch is scheduled almost exactly one year from today. SGS Thomson and ITT Intermetall are producing the silicon chips which will be the central component of radios for the WorldSpace system.
- WorldSpace has brought together world-class manufacturers to make and distribute the new radios. It gives me pleasure to tell you that we will formally announce the four companies a week next Tuesday, on June 10, 1997, at AsiaTelecom in Singapore.
- Finally, WorldSpace is gathering a huge variety of content providers to bring entertainment, information and education to a world of listeners.

A new medium - global, digital, seamless, versatile - is being built by engineers using the most modern techniques. But this new medium - and the worldwide business which it will engender - was born through a basic human impulse... the desire to help others.

My original concept was to use satellite-delivered digital audio broadcasts to stop the spread of HIV in Africa. It was the mid-1980's. Information was the only weapon which we have to fight AIDS. Direct satellite radio seemed ideal for bringing such information to Africa's widely dispersed populations. Beyond this first application, we quickly realized that

Africa was poorly served by its electronic media. Satellite direct radio would be a superb medium for filling many of the continent's informational needs: distance education, health advisories, disaster relief, agricultural instructions, even special programs for youngsters. In a very real sense, the concept of this new medium began with a socially-responsible vision.

Our first look at Africa revealed unmet needs. We looked again and saw under-served radio markets. When it came to radio, most Africans had unreliable service, poor audio quality and few choices. That raised our curiosity about other regions. So, we examined media in Asia, Latin America and the Caribbean. Here is what we learned: in the developing countries – on average – there is one radio station for every 2 million people. In industrialized countries there is an average of one station for every 30,000 people. We looked at this disparity and saw a business opportunity. Broadcasters would pay to reach larger audiences. Advertisers would pay to get messages to a wider public. Consumers would spend disposable income to get a new radio service offering quality and choice. We looked at trends and found immense potential in the developing world.

Consider the economies of Africa, the Middle East, Asia, Latin America and the Caribbean. There are:

- Millions of people who want and can afford wider choices of news, entertainment and information
- Expanding incomes and middle classes
- Growing market demand for more consumables
- Desire for knowledge and intellectual growth.

The WorldSpace system will consist of three satellites, each projecting three beams. The high power means that people will be able to receive programs directly from satellite on a personal portable radio receiver. No dish will be necessary. A small built-in antenna will suffice. Because of advanced digital compression, users will get 80 channels of high quality sound.

It all begins in one year with the launch of AfriStar 1ô, to serve Africa and the Middle East. Our satellite to serve Asia goes into orbit in December 1998. And, in mid-1999, WorldSpace service will come to the Western Hemisphere, bringing quality and choice to Latin America and the Caribbean. When humankind celebrates the arrival of the next millennium, the constellation of three WorldSpace satellites will radiate the power of information to nearly

five billion people. And – without question – we will have succeeded in creating a "new space market."

The foundation of our achievement in space will be because we remained focused on Earth-bound realities:

- We started by identifying needs
- Next, we developed an understanding in the context of markets where those needs exist
- Finally, we set about creating technologies that would satisfy the needs and appeal to the markets we had selected.

That, in three sentences, is the essential story of WorldSpace. Everything else is detail.

3. Concluding Remarks

The Book of Ecclesiastes tells us: "there is no new thing under the Sun." It conveys its message in language that betrays no compromise whatsoever. That was the biblical world view: hard and absolute. We who are born into a world shaped by Shakespeare, Newton, Voltaire, Freud, Marx, Einstein, silicon chips and TV have a far greater appreciation for subtleties, exceptions, shades of gray. The Bible's stern black-and-white pronouncements and thou-shalt-not edicts seem as dinosaurs from the psyche's Jurassic Age.

I want to leave you with a message for today expressed in an ancient style. When you build your business, look for eternal needs. The need for sustenance. The need for health. The need for harvests of crops, and collection of minerals. There are no new markets - only new methods to serve the needs that have always been and forever will be part of our lives.

Session 7

Earth Observations: Market or Public Service?

Session Chair:

M. Kabbaj, Director, Centre Royal de Télédétection Spatiale, Morocco

The Use of Meteorological Satellite Data in Africa and Their Contribution Towards Economic Development

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Abstract

Meteorological satellites provide essential data for meteorology as well as for many other disciplines worldwide. Many National Meteorological Services (NMSs) in Africa have installed equipments for the reception of meteorological data in the last two decades. In this paper a few NMSs, which are in Algeria, Ethiopia, Gambia, Kenya and Namibia, and some intergovernmental organizations, ACMAD (Niger), AGRHYMET (Niger) and DMC(Kenya & Zimbabwe), are considered. They have recognized the need and importance of satellite data to process, manage and disseminate information related to food security, desertification, crop protection, desert locust control..., etc.. The data are also used for early warning system-monitoring of an area at risk and for natural resources management. The dissemination of environmental information derived from the use of data from meteorological satellites has been realized to be cost-effective and efficient, and has contributed to improved weather information provided by the national meteorological services. However, popularization of the use of weather-related information in Africa increases awareness of such information in improving the contribution towards the socio-economic development of the continent. Moreover, it is suggested that, since many governments globally are already beginning to reduce funding to the NMSs, they should organize themselves to use marketing principles in order to increase the economic benefit to the user as well as the nation by providing user-tailored weather information using the current remote sensing techniques. User feedback information is also important to the improvement of the NMSs in contributing to socio-economic development.

1. Introduction

Meteorological satellites provide essential data for meteorology as well as for many other disciplines worldwide. Many National Meteorological Services Centers in Africa have installed the reception of meteorological satellite data in the 1980's and early 1990's. The data are used for operational meteorology and a number of environment related applications. Due to the favorable location at the center of the Meteosat field of view, users from the African continent are benefiting from the finest horizontal resolution of the visible and infrared imagery.

In the context of African developing countries, meteorological satellites help to complement the ground based infrastructure which is far from being sufficient to fulfil the operational requirements for meteorological observations. The satellites are also used in improving communication capabilities for the collection and dissemination of meteorological data and information.

African countries benefit from meteorological satellites' information in managing their natural resources. Using the rainfall estimates derived from satellite data contributed much to assessing seasonal droughts and desertification. They also provided a key input in water resources management, with all its implications for crop monitoring and food security. Satellite images have become an important tool to issue a near-real time warning against natural plagues or other events such as bush fires, floods, sandstorms and desert locust invasion in Africa. In this paper, the activities of a few National Meteorological Services (NMSs) have been considered regarding the use and contribution of satellite data to the economic development of Africa. These are Algeria, Ethiopia, Gambia, Kenya and Namibia. Moreover, some intergovernmental organizations are also considered.

2. Examples of African Countries Using Satellite Data

2.1 Algeria

The meteorological satellite data are used to improve the information for the reliable detection of sparse vegetation in arid lands, and for the monitoring of desert locust breeding areas, in addition to weather assessment and forecast purposes for other socio-economic sectors. Case studies showed that the use of remotely sensed data from low cost receivers operated by local teams able to operate then in a routine way contribute to the economic development. Satellite information is also used by local institutions like Plant Protection Services for the monitoring of ecological conditions in the desert locust recession area (Reference 1).

2.2 Ethiopia

With the growing interest of weather-related information, the importance of satellite remotesensing techniques for operational forecasting and other meteorological services to many economic sectors is ever increasing in Ethiopia. Early identifications of drought areas and issuing of early warnings on possible food shortages have become feasible. The application of satellite data to the national famine early warning, food security improvement, desert locust control, water resources development and fire detection in Ethiopia is believed to lead to a better socio-economic development of the country. The satellite-based communications of meteorological data are found to be cost-effective, efficient to provide user-oriented and timely weather information (Reference 2).

The following examples illustrate the importance of meteorological satellites:

Fire detection in Ethiopia. In the 1994 dry season (October to December) the detection of actual forest fires has been confirmed in Ethiopia by the use of fire detection based on a comparison with the surrounding background temperature of NOAA AVHRR data. This enlightened the policy makers and users to foresee the protection and preparedness of the possible fire damage in remote areas.

Flood forecasting and assessment. In the 1996 rainy season, the flood which was caused by the Awash River affected a significant number of people and damaged properties. NMSA as part of its duties contributed to alleviating the disaster caused by this flooding in collaboration with the Disaster Preparedness Commission and a group formed for the emergency of this flood under the Prime Minister's Office. The satellite information, which includes the satellite images, the meteorological data and prediction models via the MDD of Meteosat, was very important to carry out the early warning and mitigation of the disaster caused by the flood.

Agricultural application. The agrometeorological forecasts and assessments based on routine, agrometeorological observation and field visits in Ethiopia are not enough. Satellite data are used to close the gap.

2.3 Gambia

The Gambia National Meteorological Services use satellite data for assessing weather studying the health sector in Gambia. For example, the epidemiological, entomological and sociological studies on malaria have been made in order to investigate the effectiveness of the national malaria control programme. Attempts are being made to optimize the use of environmental satellite data in finding the relationship between meteorological parameters (rainfall, wind, surface brightness temperature, etc.) and malaria epidemics. The studies have shown that there is an association between malaria transmission indicators and environmental variables obtainable from Earth observation satellites. The ability of the malaria control services to respond to the information provided is of primary importance if early warning systems which incorporate satellite data are to be effective (Reference 3).

2.4 *Kenya*

In Kenya, since the coverage of conventional field observation is inadequate, satellite data are used to monitor the dynamics of vegetation on the Earth's surface. Some studies (Reference 4) indicated that synoptic coverage and multi-temporal imaging capacity of meteorological satellites, together with their relatively high spatial resolution, offer a cost-effective means of monitoring vegetation. From the preliminary results of the studies in Kenya, it is found that it is possible to predict crop yields by means of the vegetation index using NOAA AVHRR data. However, the studies emphasized that caution has to be taken for operational use of estimating accurate yield amounts since the methodology has several sources of errors.

2.5 *Namibia*

In Namibia, warnings to farmers concerning the likelihood of infestation by the small-stock nasal fly, Oestrus ovis, are issued so that farmers can then treat their stock at the most appropriate time. A study based on temperature information from METEOSAT (Reference 5) indicated that there is a better possibility of assessing the place and time of hatching and improving the reliability of warnings given to the farmers. This demonstrates the practical usefulness of free, readily available data to people in the field.

2.6 *African Intergovernmental Organizations*

The use of satellite data in monitoring drought and assisting agricultural activities in Africa is also developing in the intergovernmental organizations. Some of these intergovernmental organizations are the African Center for Meteorological Application for Development (ACMAD) in Niamey, Drought Monitoring Centers (DMC) in Nairobi and Harare, and the AGRHYMET Center in Niamey. These centers utilize the data to predict hazards and to issue early warnings. Moreover, the centers use satellite data to provide information and advice to users, including some national meteorological services in Africa, to contribute to the socio-economic development of the continent.

3. Problems and Future Prospects

3.1 *Problems*

The big problem is funding. The availability of suitable receiving and processing equipments and their maintenance is also a severe problem in Africa.

The knowledge, experience and awareness of space technology are also far from sufficient. However, some progress is being made, but the situation remains far behind that in the developed world.

Many governments are beginning to reduce funding to the National Meteorological Services (NMSs). Do they have to change from being fully government budgeted agencies to self-budgeted commercial services? Could there be commercial contributions as a core activity of meteorological services making observations and forecasts? If that is the case, they must be profitable; there is no chance otherwise for their continued existence.

It seems clear that African meteorological services are not yet capable of becoming profitable. The expenditure is high but the income is limited. Paradoxically, there is some redundancy of work and misuse of personnel, while there is an acute shortage of skilled manpower. Furthermore, the forecasts to the public via the mass-media and governmental agencies (the highest in number among the customers) are issued free of charge. On the other hand, the government budget cuts hamper the development of the services. Thus, the NMSs should organize themselves to use marketing principles in order to increase the economic benefit to the user as well as the nation by providing user-tailored weather information with the current remote sensing techniques. But many of the questions on the sources and generation of funds for the NMSs in the future are left open.

There is no suitable mechanism to receive user feedback. Establishing a strong mechanism to obtain feedback information is crucial for the improvement of the NMSs in contributing to socio-economic development.

3.2 Future Prospects

Many of the NMSs are thinking of cutting costs and searching for new means to make money. In spite of the facts mentioned above, it is true that Africa is progressing in using satellite data for its economic development. Though still insufficient, the awareness by the people and the governments in satellite meteorology shows that the future development of space technology and its use is inevitable. However, careful planning in skilled manpower development and follow-ups of technological advancement are important.

4. Conclusion

Meteorological satellite information is useful for economic developments as follows:

- The dissemination of environmental information from meteorological satellites has been realized to be cost-effective and efficient.
- However, popularization of the use of weather-related information in Africa contributes to a better use of these data towards its contribution to socio-economic development. Moreover user feedback information is needed.
- The NMSs should organize themselves to use marketing principles in order to increase the economic benefit to the user as well as to the nation, by providing user-tailored weather information using current remote sensing techniques.

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From Technology Push to Market Pull : SPOT, a Success Story

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Abstract

The motivations of the 1978 decision on the SPOT 1 satellite were definitely "technology push" but fairly soon the commercial dimension of the system appeared, which led to the creation of the Spot Image company in 1982. Spot Image was created with the objective to develop the market in order to fund the renewal of the SPOT system by its revenues and guarantee its durability. This objective is still valid. The commercial results of SPOT satellite's operation from 1986 to 1996 illustrate the success of the program, in particular on both technical and commercial levels. During these ten years, Spot Image succeeded in creating a market for satellite data and has become the leader in this market.

The three main reasons for the success of the SPOT program are: the strong and lasting wish to market the data, the quality of products and services, the continuity and the improvements of the system. Based on this success, the "market pull" approach is followed for future developments. With such an approach, the next generation of the SPOT satellites beyond SPOT 5 will be funded through both public and private sources. With a strategy adapted to a context of enhanced competition, Spot Image is able to reach its objective.

1. The SPOT Program

The SPOT program is a European program decided upon in 1978, nearly 20 years ago. Three European countries have been participating have been participating in its development: Belgium, Sweden and France. The SPOT program is usually classified within Earth Observation programs, but I prefer to classify it within information activities. In fact, because the SPOT satellites enable the acquisition of factual and precise geographical information of the Earth, the SPOT program is truly a program of the 21st century, a century where the role of information will be essential.

The SPOT program is based on the operation of several satellites in orbit. Their orbit is a polar and Sun-synchronous orbit, which enables them to acquire information all over the Earth under the same lighting conditions. This orbit has a 26 day repeat time: every 26 days, a satellite flies over the same point on the Earth. In order to improve the accessibility, the satellites' instruments can acquire information across the track of the orbit, so any point of the Earth can be acquired every two and a half days on average, depending on its latitude. After eleven years of operation, more than 5 million images have been acquired (an image covers a piece of land measuring 60 kilometres by 60 kilometres). These images are referenced within a catalogue which is accessible through Internet (http//: www.spotimage.fr). The images are acquired in the visible and near visible spectrum in two different modes: the panchromatic mode

which gives black and white images, and the multispectral mode which gives colour images in three different bands. The ground resolution of the images (the smallest detail visible on an image) is 10 metres in panchromatic mode and 20 metres in the multispectral mode. Due to the capacity to acquire images across the track of the orbit, it is possible to acquire pairs of images over the same place with two different viewing angles: with such pairs it is possible to generate Digital Elevation Models. The capacity to "revisit" a site, the high resolution and the stereoscopic capability are the three main advantages of the SPOT program.

The applications of geographical satellite information are numerous and various. The two main ones are mapping and agriculture. Mapping is obvious: with images of the Earth, it is very easy to either create maps or update them. This activity represents 40% of Spot Image's consolidated turnover and is generated in developed countries as well as in emerging countries where mapping is in general incomplete, if done at all. Agriculture is also a common activity. Two different applications generate most of this activity's turnover : statistics and control. It is possible to elaborate acreage estimates of different kinds of crops in an efficient way with satellite imagery; in particular these estimates could be elaborated earlier in the growing season than with ordinary methods. In the field of control, satellite imagery constitutes an aid for the services in charge of the control of the farmers' crop declarations. The information supplied by the images is a guide which enables field inspections to be kept down to a strict minimum (only where satellite images have shown differences between the declaration made by a farmer and the reality observed on these images). Agriculture represents 20% of the consolidated turnover. Beside these two main applications, several others could be illustrated, i.e. environmental applications (establishing areas exposed to hazards such as flooding), urban planning applications, geological applications, etc.. There are also new applications such as telecommunications (implementation of mobile telecommunications networks).

2. A Brief History

Let us now go back to the initial decision which was made in 1978. In France at that time the Prime Minister was Raymond Barre, who was on the right wing of the political scene. At the beginning the SPOT program was an experimental program. In fact the meaning of the SPOT acronym was Satellite Probatoire pour Observer la Terre (literally in English, Probationary Satellite for Earth Observation). At that time, the objective to market SPOT data had not become a priority.

The design of the first satellite was based on very innovative technology. This was the technology of linear detectors in the visible spectrum, (called CCD, Charge Coupled Device), which was an emerging technology in 1974/1975. The choice of this technology was possible because it was largely used in photocopiers, which was the essential guarantee for its survival. For instance in 1980, several million of such detectors were used in photocopiers whereas only 100 were used for the development of a SPOT satellite.

Why choose such a risky technology on a first satellite? The choice of this technology was justified by several advantages: the main one was the absence of moving pieces in the focal plane of the instrument. The geometrical quality allowed by such a technology was so high that it was possible to outdo the performances of the only existing civil Earth Observation satellites, the US Landsat satellites. The approach taken was definitely one of "technology push", with the purpose to have a decisive advantage over the only existing Earth Observation system.

The objective to market SPOT data came later with the decision regarding the second SPOT satellite, SPOT 2. This decision was made in 1981 before the launch of the SPOT 1 satellite and was, in consequence, rather bold. At that time the French Prime Minister was Pierre Mauroy who was on the left wing. (No real political consideration here, but read on.) The decision to market SPOT data was connected to the wish eventually to achieve the durability of the SPOT system by sales' revenues. The size of the market was very limited at that time because the use of such data was mainly scientific. It was necessary to develop the market. In the absence of an entity in charge of such a market, the decision to create a private company called Spot Image was made at the same time. Its role is the commercial operation of the system, from the tasking of the satellites to the data dissemination. Its main objective is still to develop the market in order to generate revenues to fund the renewal of the SPOT system.

What is the situation after eleven years of operation? The SPOT program now includes five satellites. The first three were launched, respectively, in 1986, 1990 and 1993. One of the satellites in orbit was lost late 1996 due to a problem with its attitude control system. Today the other two satellites in orbit are operated, on a commercial basis, in order to be able to fulfil strong market demands for the agricultural applications. The first three satellites are identical. The other two satellites show some developments. The SPOT 4 satellite has some improvements compared to SPOT 1 to 3. It has an additional spectral band in the short wave infrared for the multispectral mode, useful for agricultural applications. In addition a new instrument called Vegetation will

provide data over the entire Earth every day, which allows a good monitoring of the vegetation. This satellite will be launched at the beginning of 1998. The SPOT 5 satellite is a satellite of a new generation with enhanced performance; in particular it will provide images with a ground resolution of between 2 and 3 metres with a field of view of 60 kilometres. This satellite will be launched in 2002.

3. Markets for SPOT Data

Spot Image markets SPOT data through two different networks. First there is a classical distribution network which includes three subsidiaries situated in the United States (SICORP), in Australia (Spot Imaging Services) and in Singapore (Spot Asia). Each subsidiary has a local market: North America for SICORP, Australia, New Zealand and Papua New Guinea for SIS, and ASEAN countries for Spot Asia. This also includes 80 distributors located in 60 different countries. The second network is more unusual : it is the Direct Receiving Stations network which can receive the telemetry sent by the satellites and market the corresponding data in the territory where the station is located. Today this network includes 21 stations. In terms of turnover, the first network generates 60% and the second 25%. The last part of the turnover is generated by turn-key projects. Within these projects, Spot Image sells a service which includes data, software, hardware and training.

The geographical distribution for the turnover is situated mainly in three regions: Europe with 30% of the consolidated turnover between 1986 and 1995, North America and the Asia-Pacific with 22-23% each of the same turnover. Three other regions cover the rest of the turnover. The low figures in these areas do not mean that SPOT data are not used. In reality SPOT data are used in applications funded by the World Bank or the European Union and taken into account in these regions. The geographical distribution of the turnover in 1996 shows that, whilst North America and Europe have stabilised, turnover in the Asia-Pacific region has increased from 22-23% to 32%. In recent years, the three countries with the highest sales are the United States, Japan and France. Today, with 60 to 70% of the market, Spot Image is the leader in satellite imagery.

The three main reasons for the success of SPOT are :

- The first is the strong and continuous wish to market the data. At each decision regarding a new SPOT satellite, the objective to develop the market was underlined. The SPOT program has been strongly supported by

the Belgian, Swedish and French governments. In France, support was continuous despite the changeover of political power between parties: SPOT 3 was decided by Jacques Chirac (right wing), SPOT 4 by Michel Rocard (left wing) and SPOT 5 by Edouard Balladur (right wing)!

- The second reason is the quality of products and services. SPOT products are famous for their quality and in particular their geometrical quality, essential for cartography and applications based on comparison of data acquired on different dates. In addition, Spot Image has a good reputation in terms of service. Regular surveys of customer opinion are conducted in order to improve the quality of service (apparently customers are more concerned by delivery times delay than by cost).
- The third reason is the guarantee of continuous data provision and improvements. Today with SPOT 1 to 5, Spot Image can guarantee data provision for at least the next ten years. This is the only system which can guarantee such a continuity to its customers. Furthermore, the successive satellites will provide data with enhanced characteristics for the benefit of the customers.

Even if the present situation looks satisfactory, Spot Image's objective is not yet reached. Nevertheless, progress has been made since its creation in 1982. All operational costs are covered by sales' revenues; in particular, satellite control costs borne by the Centre National d'Etudes Spatiales are reimbursed by Spot Image. Furthermore, Spot Image has started to participate in the funding of the investments : the ground segment (all the equipment necessary to operate the SPOT system on a commercial basis) will be funded by Spot Image for the SPOT 5 satellite.

This has been possible thanks to the development of the market which has now reached a certain level of maturity and has a great potential. This leads to a better prediction of market evolution and knowledge of users' needs which could then be taken into account for satellite design. This is what is known as a "market pull" approach. The improvements on the SPOT 5 satellite have been designed, and the new generation of SPOT satellites beyond SPOT 5 has been studied with such an approach.

It is in this way that Spot Image will fulfil its objective. In fact it is the best way to increase Spot Image's sales revenues and reach the break-even point. The fulfilment of this objective also depends upon operational and investment costs. The lowering of these costs is one of the priorities for the design of the new generation of SPOT satellites beyond SPOT 5.

Several factors could also have an impact upon the fulfilment of this objective. The main one is the arrival of new competitors. Beyond the negative effects on Spot Image's market share, it also has positive effects. These new competitors often offer data complementary to SPOT data, which enables new applications based on the use of better data sets. In addition our marketing efforts, which will be larger, will have a higher impact on market development. The cake will be shared by more but it will also be bigger. Another factor is the arrival of new technologies, such as electronic highways, which will enable new services with a positive impact on the development of the market (for instance the near real time delivery of products).

Today, taking all these factors into account, Spot Image is very confident in its future and is envisaging a significant participation in the funding of the new generation of SPOT satellites. It is also expecting to reach its objective to guarantee the durability of the SPOT program within the next few years.

Identification of Satellite Data Application Products and User Requirements in Argentina: Influence on Strategic Planning

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Abstract

Argentina can make extensive use of data products from Earth observation satellites. This is so because:

- Argentina covers a large geographical territory
- its economic activities are strongly influenced by extensive primary products (agricultural, fishing, forestry and mining)
- its large productive areas are vulnerable to natural and anthropogenic catastrophes.

Conae, as the institution responsible for the development of the National Space Program, has undertaken a survey to determine the needs of satellite data application products in the public and private sector. The main objectives of this survey were to:

- determine the actual and future needs of the user community, to be able to organize the distribution and availability of satellite data and value-added products
- evaluate the economic impact derived from the use of satellite information products in the planning and monitoring natural resources, and
- identify the technological and information areas where there might be opportunities for innovative developments.

This paper describes the methodology used for data collection and analysis of the public and private needs for satellite data and application products. It presents the main points that result from this analysis, and indicates ways (such as matching needs with technology) in which this type of analysis could contribute to the strategic planning of the National Space Program of Argentina.

1. Introduction and Background

Remote sensing missions are aimed at gathering data and images on our continental, island and polar territories, as well as on their sea shelves, towards optimizing the use of our natural resources, preserving the environment and preventing natural catastrophes. Within this broad frame, actual and future missions focus on building and growing maturity to make the transition from research to operations. Today, customers constitute the leading edge. They demand data and products with guaranteed quality, timeliness and continuity, and supported by a growing industry of added valued operations. Future missions need to supply proven and validated information to public and private customers. Several studies have been done to assess the characteristics of the

remote sensing market and to identify who the customers are and will be, and what will they require from space information products (Reference 1).

Within this general context, the Argentine Space Program is working toward modelling the remote sensing information demand identifying the prospective users, by focusing on the understanding of the country's physical resources. In this direction, Argentina may be labeled as a "space country" (Reference 2), considering that it features as one of the countries that makes and will make intensive use of the products arising from space science and technology. This occurs because:

- It covers an extensive geographical territory, ranging from the tropics to high latitudes
- Economic activities in Argentina are strongly influenced by extensive primary exports (agricultural, fishing, forestry and mining products, plus hydrocarbons)
- Its society has a development level that requires everyday use and exchange of detailed and quantitative data on its own structure and economy
- The distinctive distribution of its population demands an intensive use of telecommunications
- Its large productive areas are vulnerable to natural and anthropogenic catastrophes
- The regional and international links and commitments undertaken by the nation will oblige it to generate and use goods and services deriving from space science and technology.

From the above points, it is clear that, in view of its own conditions, Argentina is making and will make use of products derived from space science and technology and, consequently, a definition has to be made on how to have access to them in the future. Considering its level of technical and economic development, its projection towards becoming a producer and an active user of such technology appears as logical. An "active consumer" of goods with a high technological content is understood as that having the necessary technical capacity, when purchasing, to exert an influence upon the conceptual definitions and the advantages of what is being purchased.

2. Objectives

The objective of this paper is to present the work in progress in CONAE toward establishing a baseline of information in which to plan for public and

private uses of satellite data, remote sensing value-added product developments, strategies of the Argentine Space Program, and mechanisms for the economic evaluation of its major impacts.

3. Methodology

The set of steps encompassing space data generation, transmission, processing and use has been called the "Space Information Cycle" (SIC) (Reference 3). Along this cycle, space activities operate either as use promoters or as suppliers or consumers of both the data itself and the means for its production, transmission, elaboration and storage. The National Space Program in its goals established the developing of a complete Space Information Cycle. The concept under this statement entails the development of missions and activities that will fulfilled the spatial information needs of Argentinian users. In this direction, the space program is putting its efforts into identifying what those needs are; it will try to develop missions that will address and satisfy those needs.

An information platform is being undertaken to assist in the identification of the needs and requirements of Argentina's space missions. A data base, where the geographic dimension is also included, is being built with the following objectives:

- to outline the different problems brought by the economic sectors and that require the cooperation of CONAE and the Space Program
- to identify thematic application products which need satellite information as the major input
- to quantify the economic impact of these products, by identifying adequate economic indicators
- to identify and define channels (public and private) through which CONAE will make possible the diffusion and use of satellite information products.

Prior to the construction of the data base, a conceptual model of the information flow expected within the Space Information Cycle was developed (Reference 4). This conceptual frame provides the means to understand the remote sensing information requirements, and their relationships with the uses of the information. Figure 1 represents a particular view of the complete Space Information Cycle. In this scheme, there are information stations, where remote sensing data are generated, received and/or stored. Arrows indicate the flow of demand and service transfer processes of satellite data requirements.

The information stations considered are:

- **Bio-physical environment**. This represents the physical resources, natural and man made, and their conditions, as well as the environmental variables that act upon them. These are sources of reflected, emitted and backscattered electromagnetic energy which can be detected by remote sensors. The electromagnetic energy patterns can be processed and analyzed in order to obtain information about the characteristics, condition and dynamics of the environment.
- **Sectors.** They represent the different productive sectors from the economic, political or academic worlds. They need information about the environment to take decisions.
- **Data providers.** Companies or public institutions that provide geographic information to the decision makers. These data providers offer, at different processing levels according to the human skills, the hardware and software capabilities.
- **Satellite operations**. This includes all actors involved in data capture. They are responsible for designing, planning and operating missions (receive the data, store, process and distribute).
- **Sensor Platforms**. These are the remote sensing systems themselves.

The interchange of data between stations is considered as follows:

- **Issues**. These are the different situations (crop monitoring, flooding control, etc.) that determine the information request. Due to natural or anthropogenic factors, information is needed to follow a condition, or assess the magnitude of a disaster. They include a large variety of subjects and as a result of information needs.
- **Decisions**. If the information is provided at the right time and place and at the level of processing required, it will generate a decision making process.
- **Environmental information needs**. The issues within a sector determine the type of data required.
- **Satellite information products**. They are a set of processed data that a data provider offers in response to a requirement. There are information solutions that can be presented in a number of different ways, such as thematic maps, risk analysis, etc.
- **Order of satellite data**. This is the request for raw or pre-processed satellite data.
- **Earth observation mission planning**. This covers a great number of activities, from mission planning to mission operation by request.

- **Process involving reception of satellite data.** The reception of data from satellites (at receiving stations) includes hardware and software capabilities for data reception and storing.

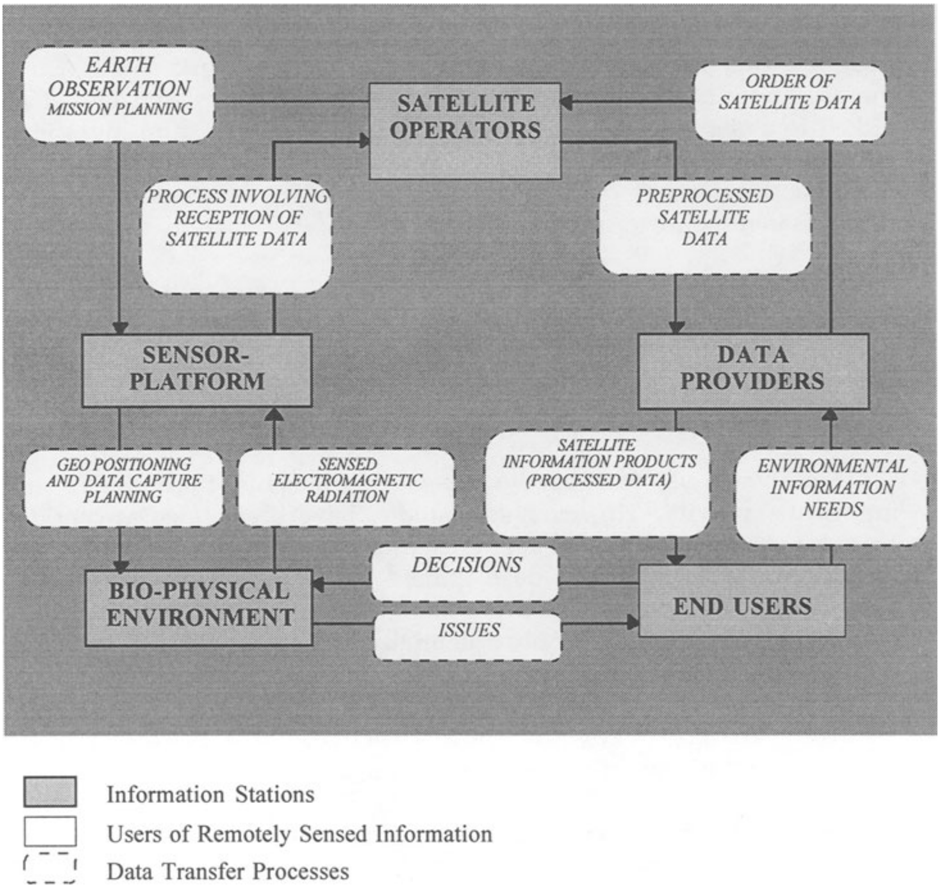

Figure 1. Conceptual model of the information flow in the Spatial Information Cycle

This model provides the basis on which the data base is being built and where the interactions between components are defined.

4. Results and discussion

The survey program is based on the analysis of the main public programs that are using, and will use, remote sensing information, on some of the current and potential private customers of the major Argentinian productive areas, such as agriculture, mineral and forest resources, oil and gas, and on the demands of the aid and funding agencies. The information is being stored in a data base linked to a Geographic Information System that allows us to investigate the spatial distribution of customers and problems. This also helps in identifying public and private groups capable of being able to generate value added products in response to specific demands.

As the next step, each application product is linked to the key parameters that could be measured from a satellite sensor, in order to match these parameters with existing systems that could address the subject or, in case no systems are available today, identify possible opportunities for innovative developments.

Finally, it is necessary to assess the benefits that derive from an innovative activity. However, such studies have been aimed at considering it as a long-term investment, and thus estimating an internal rate of return associated to research and development activities, innovation and related services. On the basis of these estimations, it may be stated that the space program in Argentina is not only potentially sustainable by the local economy, but may also result in significant benefits.

There are three ways in which space activities may be considered in order to justify a public investment program in this field:

- as managers and promoters of development issues that are transferable to commercial activities
- as research, development and innovation tasks
- as direct producers of commercially valuable goods and services.

Space activities have proved to be a setting for the development and full growth of new technological concepts that, in a further stage, when adopted by the production sectors in society, have given rise to a high technology industry sector capable of obtaining good results in the global market.

Space activities are also producers of goods and services with a commercial value, among which are all those activities derived from remote sensing

applications. Nowadays, the major segment of demand is the public sector. Although this fact is not expected to change drastically in the near future, it may be foreseen that, in the medium term, some areas of the data obtained by remote sensors will go into a commercial stage and will be handled somehow as satellite communications systems are managed today. Meanwhile, this market should consolidate in our society through the creation of an independent entrepreneurial sector highly specialized in the use of these means. Thus, it would produce a simultaneous benefit to society through the diffusion involved in the use of such data. These facts being taken into account, consideration must be given to a first promotion stage, which will require support from the public sector and, at the same time, a stimulation of private participation in any possible way.

The areas whose profiles show the most direct economic impact in the short and medium terms are:

- the follow-up and qualification of agricultural and forestry production
- the follow-up and surveillance of fishing activities
- the supervision of floods and natural disasters
- the evaluation and survey of soil conditions
- the evaluation and exploration of mineral, gas and oil resources
- the monitoring and supervision of environmental problems.

Additionally, there are other secondary markets connected with remote sensing that, due to the early phase of their use in the country, are difficult to quantify:

- The market of geographical data systems and their related data bases
- Global climate reporting and forecasting
- The market of special sensors.

In addition to constituting a valuable base of general information, the use of remotely sensed data in agriculture may give rise to more accurate forecasts of future harvests, to a better control of promotion loans and of tax collection, and to a better use of subsidies on natural disasters. As an example, it may be mentioned that, when correlated with climatic factors, a detailed historical data base on agricultural production should serve as a basis for a market of agricultural insurances, an activity that is now practically non-existent.

In the fishing area, the use of satellite data may result in more effective campaigns and in fuel savings due to the location of areas of high fishing

density. Appropriate satellite data are also indispensable for the surveillance and control of fishing licenses concerning operations in the Argentine Sea and for the supervision of over-exploitation of fishing resources. Remote sensing in the mining field would contribute with significant savings in exploration campaigns, and in controlling the environmental impacts of such developments.

The Argentine Space Plan, in its formulation, states that it has to be reformulated every two years. Therefore the information system being built has been designed toward optimizing the procedures for reconsidering the planning of the space program every two years.

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Satellite Remote Sensing and Maintaining Environmental Security: The Market Perspective

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Abstract

Recent research into the connections between environmental degradation, resource scarcity, and increased chances of human conflict has suggested that the combined effects of renewable resource depletion and degradation, increased population density, and unequal resource distribution could lead to conflict, both within countries and among them. Surprisingly, researchers have devoted relatively little effort to understanding how satellite applications may assist in improving environmental security. In some critical regions, the development of new methods to avert and/or mitigate adverse environmental changes may assist in mitigating future conflict.

This paper explores the potential for using remotely sensed data to improve scientific understanding of the factors that lead to environmental degradation. It also examines how this information could lead to early warning of regions of possible conflict. Maintaining environmental security is closely allied to the attainment of sustainable development. Hence, this paper also discusses the use of remotely sensed space-based data to inform policy makers about potential paths to sustainable development and to monitor their success in achieving sustainable development goals. Such uses constitute an important new market for satellite data, serving both public and private users. This year, several companies will begin to market remotely sensed data from privately owned satellite systems. These data will be of considerable use for identifying and analyzing environmental degradation, and in crafting workable solutions. This paper analyzes the market opportunities and constraints for such data.

1. Introduction

Over the past decade, analysts have begun to explore the relationship between local and regional environmental degradation and the security of social, political, and economic institutions, particularly in developing countries. Indeed, recent research into the connections between environmental degradation, resource scarcity, and human conflict has suggested (Reference 1) that the combined effects of renewable resource depletion and degradation, increased population density, and unequal resource distribution could lead to conflict, both within countries and among them. Other commentators (Reference 2) have emphasized the relationship between environmental security and sustainable development. These scholarly efforts are part of the thrust to redefine security after the Cold War.

In the United States, the perceived importance of environmental issues in international and security affairs has caused the Department of Defense (DOD), the Department of State, and other federal agencies with national security concerns to increase their attention to the environment. The DOD's

Office of Environmental Security is attempting to reduce the "environmental footprint" of the U.S. military at home and abroad. In April 1996, former Secretary of State Warren Christopher affirmed the growing importance of global environmental matters to American diplomacy. Environmental security played a significant part in his thinking (Reference 3). The U.S. Department of State has integrated environmental issues into all phases of the planning and conduct of foreign policy (Reference 4). U.S. foreign policy, environmental, energy, and defense officials are working with their counterparts throughout the world to share information about environmental issues that might affect security and to learn new techniques for coping with environmental problems.

The term environmental security has been used in at least three primary contexts (Reference 5): to denote *security of the environment* from degradation caused by human activities; to signify *the impact of environmental change on economic and social institutions*; and to indicate *the potential for environmental degradation to assist in undermining political stability* and thereby threaten the security of nations either directly or indirectly. Whichever meaning one imparts to the term environmental security, it is fundamentally concerned with the effects of human decisions and actions on the environment and, in turn, how environmental changes may affect human behavior.

2. Remote Sensing and Environmental Security

Surprisingly, researchers have devoted relatively little effort to understanding how data acquired from spacecraft and other satellite technologies may assist in improving environmental security. In 1996, the Space Policy Institute of The George Washington University held two interdisciplinary workshops to explore the potential for using remotely sensed data to enrich scientific understanding of the factors that lead to environmental degradation. The workshops also examined how such information could lead to early warning of regions of possible conflict. The workshops examined questions such as:

- What are the most important environmental factors to examine in improving environmental security?
- How can Earth science research assist in understanding environmental changes that might engender violent conflict?
- How can policy makers make better use of such data and information to enhance environmental security?

Several major themes relevant to the development of the remote sensing market emerged from the discussion and from additional analysis by the author:

2.1 *Putting scientific results to work in applied settings will require, among other things, increased attention to the communication of results to managers, policymakers, and others directly affected.*

Scientific results from environmental studies will be of little utility to resource managers, policymakers, individual farmers, and others, unless they can be presented in forms that these groups can readily understand and incorporate into their processes. Geographic Information Systems (GIS) technologies have emerged over the last decade as important tools of analysis for any data having a geographic basis. GIS and other analytical tools, including visualization techniques, also provide the basic means to present research results to policy makers and resource managers.

Imagery by itself has the power to convey the message of environmental change to a viewer. For example, a decade of encroachment into the heavily forested northwest Peten of Guatemala from Chiapas, Mexico, or deforestation along roads in the Amazon are readily recognized on Landsat images of these regions. However, such images can also deceive because they do not in themselves convey sufficiently detailed information about the causes of such change. Turning remotely sensed images into information adequate to underpin policy decisions requires extensive analysis and the ability to convey such results to individuals with a wide variety of backgrounds.

In order to realize the full potential of these technologies, scientists will have to put a great deal more effort into how to use them in sharing their research outside the scientific community. To be of service to policymakers, such information needs to be timely and reflect local capabilities and conditions, as well as political and jurisdictional realities. In turn, the input or feedback of these "end users" of information will help the research community to refine its research questions and to direct research along the most fruitful lines of inquiry. Ultimately, the most effective approach will be to consider the overall questions of improving environmental security and achieving sustainable development as a complex system, where the system elements may interact with each other in a non-linear manner; in other words, small changes in one part of the system could produce dramatic responses in another. Planners will need to identify the most critical factors to be addressed.

2.2 Researchers will need to devote additional attention to identifying the specific data needs for environmental security and locating data required for tackling research and applied goals.

Despite more than a decade of intense research on environmental issues closely related to environmental security, significant data needs still exist in nearly every region of the world (table 1). A research strategy should focus on in-depth studies of a few, highly diverse, highly vulnerable areas. It should also build a basic data base that can be applied broadly.

Data Type
• land use/cover (extent and rate of change) • soil types/constituents • atmospheric composition • topography • demographics • water (surface and subterranean) • climate trends • infrastructure characterization

Table 1. Overall data needs

2.3 Accurate base maps of land cover and land use over broad regions would provide a crucial foundation for research and applications.

Few regions of the world are mapped at sufficient scale and detail to characterize adequately their land cover and land use. Land cover maps will assist researchers to establish a baseline from which to work in identifying and understanding changes in environmental characteristics. Maps of land use require imagery of higher resolution than necessary for most land cover studies and complementary in situ data; hence, land use inquiries will generally focus on smaller regions. The North American Land Cover project (Reference 6) and the project to create detailed land cover maps for a series of Global Land Cover Test Sites (Reference 7) serve as excellent models of what can be done to characterize regional land cover over large areas.

2.4 Food security related to marine productivity should receive more attention than it has had.

Investigating the environmental health of coastal areas, especially for parts of Africa, Asia, and Latin America where seafood constitutes a significant percentage of food resources, will be especially important. Seafood

is a major component in the diet of coastal nations but, compared to agriculture, relatively little effort has been put into studying how to improve the sustainability of coastal harvests, including aquaculture. Pollution from agricultural runoff, industrial and household wastes, the draining of crucial wetlands, and overdevelopment have seriously undermined the productive capacity of many coastal areas. In some regions, such factors threaten to destroy this source of sustenance altogether.

Ocean color data supplied by satellites can assist in identifying and tracking areas of highest productivity, and can signal areas of declining resources in need of improved management. One promising area of research concerns reducing the vulnerability to the effects of seasonal to interannual changes on ocean productivity. In particular, how does the El Niño Southern Oscillation (ENSO) affect the productivity of shallow coastal waters? Satellite data are particularly useful in following the onset and effects of El Niño.

2.5 Much more effort needs to be applied to overcoming the barriers to making effective use of remotely sensed data and analytical tools.

Despite the extensive amount of data and the analytical tools already available to researchers and applied users, significant barriers exist to making more effective use of them. Considerable uncertainties exist outside of the scientific community over what data are available and how to use them to tackle environmental security issues and to support sustainable local and regional practices. NGOs and other groups have heretofore made relatively little use of the data because of the various technical and institutional barriers that have impeded their past efforts to incorporate them in their work.

Currently, few data can be acquired, distributed, and analyzed quickly enough to be useful in realtime applications. The new satellite systems, launched by governments and private enterprise, will make vast improvements in customers' ability to acquire more timely data and in their capacity to access and process them quickly enough to employ the resulting information in local and regional decision making. In the meantime, historical data, which are already available through several networks, are extremely useful in understanding the basic chemical, biological, and physical processes that underlie changes in the local and regional environment.

3. Environmental Security Research, Development, and Applications

Mitigating the effects of environmental scarcity or developing the methods to restore a degraded resource base requires an approach that takes into account complex environmental conditions in the affected area. Soil type, water quality and availability, and other local factors will affect the choice of methods. Partnerships with agencies and non governmental organizations (NGOs) that have direct field experience are critical to success in transfering scientific results to applications.

Even with little government support or involvement, humanitarian and development NGOs could well use the results of this research to enhance their efforts in the sustainable management and use of resources. Problems of environmental degradation are often based on mismanagement of resources, and lack of education about best environmental practices. Because they generally work directly with local experts, NGOs are in good positions to design and urge better local and regional management practices. For example, drought-resistant seeds could be planted during years when satellite data predict a high probability of drought, despite their higher costs.

4. New Markets for Data and Information

The precise relationship between environmental degradation and national security is kept under close scrutiny, both by proponents of the concept and those who are highly skeptical of it. However, if the proposed connections bear up under more detailed research and analysis, I foresee the potential for a substantial new market in data, analysis, and display. Although much of the current interest in new remote sensing capabilities has focused on the data component, environmental security concerns will also create an expanding market for a variety of value-added services; the process of turning satellite and other complex data about the Earth into useful information requires the development of new analytic methods and techniques for displaying research results in user friendly formats.

4.1 The Customers

The customers for better environmental information include government civilian, security, and humanitarian agencies, international agencies, local and regional NGOs, and profit making companies. They also include countless individual land holders who could benefit from access to better information,

simply displayed. Each of these market segments has a potential role in improving environmental stewardship and human life.

4.2 The Available Data

The increasing availability of remotely sensed data, analytical tools, and the associated information infrastructure allow more detailed studies of larger geographical areas than before. Many satellite systems provide many sources of multispectral and synthetic aperature radar (SAR) data.

Often overlooked is the contribution that private, high resolution imaging spacecraft and distribution systems are likely to make to the market, and to the ways in which we use remotely sensed data. In order to realize a profit, these firms will have to create innovative ways of reaching potential customers. Their success, in part, will depend on whether these companies see themselves as imbedded primarily in the market for space technology, or as a small part of the much, much larger information industry. In 1997, at least one U.S. company will begin to market remotely sensed data from a privately owned satellite system. These data, which are multispectral and of relatively high resolution, will be of considerable use for identifying and analyzing environmental degradation over small areas, and in crafting workable solutions.

The challenge for these new data providers will be to market data and data products effectively. This could mean, for example, developing a variety of standard data products of interest to their major customers and making raw data available quickly and efficiently to value-added information providers. The value-added providers have the challenge of developing specialized information products for niche markets. The commercial sector could assume a leadership role in providing analysis and implementation for operational applications and should be involved in every step of the process, from research to final data product delivered to the customer. That will require a stronger alliance between the science community, NGOs, and commercial entities than now exists. For example, it may in the near future be possible to exploit the observed teleconnection between El Niño Southern Oscillation (ENSO) and crop production in Southern Africa (Reference 8) to enhance regional food security by improving climate predictions. Private companies could develop specialized information products, based on local as well as broad regional data, that would assist localized regions. Such information products would have to be inexpensive and simple to use to be effective in developing economies.

5. Conclusions

Entrepreneurs face both opportunities and challenges in developing new markets for data and information related to environmental security. Environmental security research needs a variety of data of different spatial scales, spectral characteristics, and temporal coverage to support applications projects. They will have to deliver the data and information quickly and efficiently, and deliver them in forms that can be used by a wide variety of customers. The latter criterion will require the creative use of sophisticated information tools to develop a variety of simple outputs. The development of this market will depend on success in moving from intensive environmental security research to detailed applications products. A strategy for carrying this out will depend on the inputs of university and government research, governmental organizations, NGOs, and private firms.

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Into the 21st Century With Industrial Partners: The Indian Experience and Perspectives in Earth Observation

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Abstract

Space programmes worldwide are poised for a transformation into a mature scientific as well as an industrial sector, with multiple players and changing roles. Earth observation, which began as a small scale activity aimed at mapping the Earth's surface features, is becoming a commercial activity, comprising of satellites and their operational utilisation for a variety of resource management applications, apart from systems for data acquisition, dissemination, processing and information generation. The increased thrust on commercialisation and industrial investment is leading to a scenario where the developments are being increasingly determined by market forces. A stagnation or even decrease in the governmental assistance is expected the world over, making it necessary to have private investments as a major source for financing applications and commercially driven activities. On the other hand, the increased awareness about the potential and prospects as well as the reduction in governmental controls is paving the way for multiple players, including private agencies operating satellite systems for Earth observation. Industries who used to be involved primarily in the execution of specific tasks which were more of contractual nature, playing a supportive role, have to become a user, a beneficiary and multiplier in the commercial arena. These changes are expected to accelerate in the coming years, where 'economics' is the buzzword and the dualism between strategic co-operation and competition is becoming the order of the day. In other words, the evolution of a new set of relationships between space agencies and industries has already begun, leading to a vibrant commercial market.

1. Global Earth Observation Market: An Emerging Scenario

Efforts towards harnessing the commercial opportunities associated with space efforts attained attention in the 1980's. These efforts were primarily oriented towards developing the spin-off market. Though attempts were made in the area of Earth observation too, the required momentum was achieved only in the early 1990's, which was more or less synonymous with the phase transition in the utilisation of this technology from mapping to decision making. During the 1980's not only were there fewer missions; but also their capabilities and resultant application potentials were lower than more recently. On the other hand, 35 missions carrying more than 90 instruments with varied capabilities and resultant application potential are planned by the international community in the next 5 years. Further, during the 1980's, the awareness about the potential of space-based remote sensing techniques was confined mostly to the developed world where, in fact, the commercial opportunities associated with satellite remote sensing are comparatively less.

This is mainly because of the availability of reasonably accurate and periodic information about the natural resources. Today, the situation has undergone a drastic change where remote sensing is being used as an invaluable aid by a number of countries, across the world. Consequent upon increased anthropogenic activities, there has been a considerable increase in the application needs, such as Environmental Impact Assessment, Urban Management, Infrastructure Development and so on, calling for accurate and periodic information in a readily usable format as a necessity for decision making. Recent years have also witnessed an increased awareness about the need to initiate global efforts towards the protection of Planet Earth and its environment through sustainable development and the optimal utilisation of resources. The inevitable role of space-based observations in this regard is now widely accepted.

Yet another major factor that has accelerated remote sensing applications and enhanced the commercial opportunities is the revolutionary changes which have taken place in the area of information technology. Apart from the tremendous advancements in capabilities, this has also led to new and efficient tools such as that of GIS, for interpretation, analysis and modelling. As a combined effect of these factors, the commercial remote sensing market has undergone dramatic changes indicating more active and vibrant years ahead.

1.1 India as a "Provider"

More than three decades of concerted efforts have led to the realisation of an end-to-end capability, consisting of the space segment, ground infrastructure as well as a convinced and committed user segment. The experience and expertise, developed and demonstrated, in almost every aspect of remote sensing technology development and utilisation has enabled India to attain a unique status amongst other space faring nations. The success of a series of Indian Remote Sensing Satellites (IRS), including that of IRS-1C, and the global dissemination of data has been a major accomplishment in the global remote sensing market.

A unique constellation of satellites. The Indian remote sensing programme had a modest beginning in the early 1960's when aerial platforms were used to acquire information about the Earth's resources. The impetus provided by the initial experience led to the definition of Bhaskara satellites which had a two band TV payload for land applications and a Satellite Microwave Radiometer (SAMIR) for oceanographic/atmospheric applications. In order to ensure that the operational satellite missions are defined by user requirements and the application needs, a series of experiments was conducted which led to the

successful launch and operation of IRS-1A in 1988. The various Indian remote sensing satellite missions include:

IRS-1A. Launched in 1988. Two cameras, Linear Imaging Self Scanner (LISS)-I and LISS-II, providing imagery in four spectral bands in the visible and near infrared (NIR) region, with a spatial resolution of 72 m and 36 m, respectively. Presently dormant.

IRS-1B. Launched in 1991. Identical to IRS-1A it continues to provide high quality data even beyond its design life of 3 years.

IRS-P2. Launched in 1994, using the developmental fight of India's Polar Satellite Launch Vehicle (PSLV). Carries a LISS-II camera in a three band option, with a spatial resolution of 33m.

IRS-1C. Launched in 1995. A panchromatic camera with 5.8 m resolution, a LISS-II multispectral camera with 23 m resolution and a Wide Field Sensor (WiFS) with 180 m resolution and 810 km swath operating in the red and near infrared bands.

IRS-P3. Launched in 1996 with WiFS, a Modular Opto-electronic Scanner (MOS) and X-ray payload onboard.

IRS-1D. Scheduled for launch in September 1997 and identical to IRS-1C.

IRS-P4. Scheduled for 1998 carrying an eight band Ocean Colour Monitor (OCM) and a Multifrequency Scanning Microwave Radiometer (MSMR) in 4 frequencies, with resolution varying from 40 - 120 km.

IRS-P5. Scheduled for 1999, with a panchromatic camera having 2.5 m resolution and fore-aft stereo viewing capability.

IRS-P6. Planned for 2000 with 23 m resolution multispectral LISS-III, 6 m resolution multispectral LISS-IV, and a four band WiFS camera with 80 m resolution and 800 km swath.

These apart, efforts are now underway to define missions beyond 2000 AD. While it is decided that the continuity of data and services will be maintained through follow-on missions with improved features and capabilities, the direction for the future is towards realising a unique constellation of state-of-the-art satellite missions, providing data over a wide range of the

electromagnetic spectrum, catering to the varied requirements of the user community.

Applications at grass-root level. The applications-driven approach adopted from the very beginning of the Indian Space Programme led to the adoption of a strategy where the aspiration of the user community formed the central theme. Also, an excellent interface was established with the user community paving the way for their active involvement right from the experimental phase up to the operational utilisation of this technology for various applications at grass-root level, including various stages of the definition and realisation of satellite missions. Today, space based techniques have been successfully integrated with conventional systems enabling the operational utilisation of remotely sensed data in a number of resource management areas, covering almost every facet of sustainable resource development. These include crop acreage and production estimation, crop condition assessment, pest and disease surveillance, soil resource mapping, inventory of water resources, snow-melt runoff forecast, ground water targetting, diagnostic analysis and performance evaluation of irrigated command areas, reservoir sedimentation and storage loss assessment, drought monitoring, flood inundation mapping and damage assessment, identification of flood risk zones, mineral targetting, coastal zone management, identification and forecast of potential fishing zones, environmental impact assessment (EIA), site selection for setting up new industries, infrastructural development planning, urban sprawl monitoring and management, and so on. Under the Integrated Mission for Sustainable Development, locale-specific developmental plans for land and water resources are being generated by integrating space-based inputs with collateral data. These developmental plans are being implemented with the active involvement of government departments, non-governmental organisations, voluntary agencies as well as farmers. Thus, three decades of concerted efforts have not only enabled the successful utilisation of remote sensing for a variety of applications, but also made this technology an integral element of developmental planning and decision making.

1.2 India as an "Enabler"

Thanks to the dedicated and determined efforts of the last three decades, India's remote sensing programme has become one of the most successful in the world, with end-to-end capability ranging from state-of-the-art space and associated ground segments to grass-root level applications. The expertise and the vast experience gained over the years could be utilised by interested agencies/organisations on a mutually beneficial basis. Besides the extensive

infrastructure set up to realise satellite systems, 23 State Remote Sensing Applications Centres and 5 Regional Remote Sensing Service Centres have been established, in addition to the facilities available with the various user agencies/organisations for effective utilisation of remotely sensed data. Possibilities exist to utilise the Indian capabilities to strengthen the efforts of other space faring nations/organisations. Training and human resource development, joint technology development programmes, facility support, etc. are some of the examples in this regard.

1.3 India as a "Market"

The geographical extent of 329 million hectares (Mha), covering diverse terrains characterised with varying topographic features and typical developmental needs, makes remote sensing an inevitable tool for developmental planning and sustainable resource management in India. The demonstration of remote sensing capability through a large number of pilot projects and the excellent interface established with a wider section of the user community has created considerable awareness, leading to the operational utilisation of remote sensing techniques in a number of resource management areas, which in turn has paved the way for the realisation of a convinced and committed user segment. Table 1 provides a broad outline of the resource management needs, remote sensing (RS) capabilities and the potential services in different sectors of natural resources management.

2. With Industrial Partners : A New Perspective

Having accomplished a reasonably self-reliant and operational programme, the emphasis in the coming years is on capitalising upon the established capability and capacity, apart from advantageously utilising the competitive edge established in the global market. The increasing responsibility of the organisation and the associated tasks to meet the primary mandate leaves less leverage to harness the commercial market, without an active industrial partnership. The Indian Space efforts place considerable emphasis on developing industrial partnerships, to be an active player in the commercial market. The establishment of Antrix Corporation, as a commercial front of ISRO in 1992, was a major initiative in this regard. In a short span, Antrix could make a dent in the international commercial market through strategic alliances and the supply of systems, components as well as services.

Scenario	RS capability
Agro-based •Net sown area of 142 Mha; foodgrains & oilseeds - 123 Mha •51 food crops & 15 non-food crops •435 installed sugar factories •196 Regional Rural Banks (RRBs) & 272 scheduled commercial banks •Annual credit support by RRBs - Rs.5250 crore •7.68 Mha under cotton; nation losing 60 lakh bales annually due to technology gap in production & processing •19-20 Mha under oil seeds •Second largest producer of fruits & vegetables; less than 1% processed •12 Mha under horticulture; 100 MT production •Economic liberalisation leading to more food processing units, post-harvest centres •Increased number of agro-based industries engaging in contract farming	•Vegetation condition & health monitoring •Crop acreage and production forecast •Feasibility studies for agro-based industries •Assessment of raw material availability and fluctuations •Evaluation of land capability/suitability for crops •Site suitability studies for processing industries & post-harvest operations •Damage assessment for crop insurance •Economic appraisal for agricultural credit services •Identification of cultivatable wastelands for agricultural extension •Meeting the information needs •Land degradation studies •Soil resource mapping
Farm management •16.67 lakh land holdings of >10 ha size •11.75 lakh ha under plantation crops •A number of plantation Corporations Boards: Rubber Board, Tea Board, Cashew Development Corporation, Spices Board, Coconut Development Board •Demand for scientific inputs on land/water utilisation and management	•Scientific inputs for improved farm management •Generation of information Database and Decision Support System (DSS) •Change monitoring •Valuable information for planning, decision making and market intervention
Water resources •100% access to safe drinking water by 2000 AD - a major goal of the nation •Assessment of water resource availability for major industries, large agricultural farms and at village level - a major challenge •I67irrigated command areas covering an area of 20 Mha •54 Command Area Development (CAD) Authorities, managing 189 projects •A number of water resources projects related to irrigation, power, etc., being planned •Water quality mapping & monitoring as a necessity •Watershed development emerging on the national agenda •38 projects, identified for inter-river basin water transfer	•Identification of groundwater potential zones •Diagonostic analysis and performance evaluation of irrigated commands •Capacity evaluation and storage loss assessment of reservoirs •Alignment of canals, pipelines, etc. •Techno-economic appraisal of water resource projects •Environmental impact assessment •Locale specific prescriptions for watershed development •Water quality mapping and monitoring •Decision support systems for CAD authorities •Inter-river basin water management including canal alignment and siting of structures •Snowmelt runoff forecast

Urban •3800 towns and cities •23 cities with more than 1 million population •42 million urban households •12.1 million urban households have an annual income >Rs.36,000 •Annual tourist arrival of 14 lakhs	•Urban sprawl monitoring •Urban suitability zoning and developmental planning •Utilities planning •Alignment of roads, pipelines, etc. •Preparation of city guide maps •Identification of waste disposal sites •Identification of sites for sewage treatment plants •Decision support systems for urban planners & decision makers
Utilities management •Since 1951, road network has increased just 5 times as against 75 times growth in vehicle population •66000 km highway network and 10000 km expressway network are planned by 2001 AD •Substantial increase in Telecon transmission network to realise 20 million connections by 2000 AD •Telecon connectivity to all rural areas •Potential for mini-hydroelectric projects is estimated at 5000 MW	•Techno-economic appraisal •Feasibility studies •Alignment planning •Assessment of terrain suitability •Road network planning •Telecom network planning •Techno-economic appraisal & site selection for mini-hydroelectric projects
Exploration & mining •India produces 84 minerals •4400 operating mines; around 300 are major ones •Annual demand for petroleum products is estimated to increase from 30 MT to 103 MT by 2001 •Geological reserves of over 5000 MT of hydrocarbons	•Mineral prognostics •Identification of sites for exploration •Preparation of detailed mine working plan •Environmental impact assessment •Coal fire detection & monitoring •Development of geological information systems for decision support •Infrastructural development such as alignment of pipelines, setting up of past facilities, etc.
Coastal & fisheries •An extensive coastline of 7500 km •A large shipping industry with a fleet strength of around 450 vessels with 6.28 million Gross Registered Tonnage (GRT) capacity •11 major and 139 minor ports •Extensive scope for inland fisheries; 414 Fish Farmer's Development Agencies (FFDAs) & 38 Brackishwater Fish Farmer's Development Agencies (BFFDAs) •Coastal zone - an area of strategic importance	•Formulation of coastal zone management strategies •Assessment of site suitability for aquaculture •Monitoring of shoreline changes •Identification of potential fishing zones •Development planning of ports/harbours •Navigation information for shipping companies

Environment & forest •20 categories of polluting industries need clearance for siting •EIA studies becoming mandatory and inevitable •About 19% of total area under forest	•Assessment of environmental suitability •Environmental impact assessment •Change monitoring •Forest monitoring and management
Disaster management •40 Mha of the country is flood prone; 75% protectable through appropriate watershed development programmes •On an average 1430 lives are lost and 30 million people are displaced annually due to floods •13.2% of total geographical area as a drought frequency of less than 3 years •55% of total geographical area is arid or semi-arid	•Flood damage assessment •Flood plain management •Drought monitoring •Drought mitigation
National Resources Information System - NRIS •Information one-stop shops at district level •Spatial and non-spatial information for decision making	•Generation of GIS database at district, state, central level •Development of resource information model for information output •DSS development

Table 1. Resource management needs and remote sensing capability: note that lakh indicates 10^5 and that Rs. 5250 crore means 5250×10^7 rupees

The broad objectives of the Indian commercial efforts in the remote sensing area are:

- Ensuring high quality data through a unique constellation of satellites and associated services
- Widening the spectrum and size of the remote sensing user community, covering a wide range of applications
- Realising a convinced and committed user segment
- Realising a strong and committed industrial base which not only caters to the increasing needs of the user community but also develops new market segments.

There are thus opportunities for the development of the following categories of industrial partners:

- **User.** An organisation using information on the Earth and its resources for various purposes. Users acquire remote sensing data as an aid in decision making and as a complement to conventional data.

- **Service provider.** An organisation undertaking remote sensing based projects for other clients who do not have the facility or expertise. This category generally meets the needs of the user community, spread across the nation.
- **Solution provider.** An organisation providing solutions basically to assist the data interpreters/users. These organisations concentrate on the development of software, supply of hardware, etc.. They can also undertake jobs such as database creation, digitisation, etc.. Basically, this category caters to the needs of the first two categories.
- **Promoter.** An organisation, or even an individual identifing a potential user, convincing him and initating a project which could be executed mainly by a service provider. A promoter can also take up specific promotional tasks such as advertisement campaigns, organisation of promotional workshops, etc..
- **Facilitator.** A person primarily addressing the market segment which depends on value added services/products, in other words, pre-processing of data products, generation of digital elevation models (DEMs), digital terrain models (DTMs), merged products, etc., preparing stereo products and updated contour maps, the availability of which is often critical for the user.
- **Enabler.** A person providing orientation courses, training programmes, short-term and long-term courses, etc., and marketing these.
- **Participant.** An organisation or person contracted to execute a specific task within a specified period of time, as per the specification of ISRO/Department of Space (DOS).

3. Conclusion

The world's space programmes, in particular Earth observations are moving towards a market driven endeavour, with multiple players and changing roles. The advent of advanced satellite missions, with varying capabilities and resultant applications, as well as the increased awareness about the potential benefits of this technology are paving the way for new opportunities. The Indian remote sensing efforts have made considerable progress in realising an end-to-end capability, ranging from a unique constellation of satellites and associated ground infrastructure to the operation of a number of applications at grass-root level, making India a provider as well as an enabler in the commercial remote sensing market, apart from being a vast market in need of data and services. The Indian efforts in the coming years will lay considerable emphasis on playing a role crucial in expanding and serving the user community with the active involvement of industries through strategic

alliances, cooperative arrangements and new initiatives. It is expected that these efforts will lead to a vibrant commercial remote sensing market in the coming years.

Report on Panel Discussion 7

Earth Observations : Market or Public Service?

Panel Discussion:

Status today

- Only the governmentally funded data get used by the regions of North America, Asia-Pacific and the Middle East
- In general there are many images which are not used

Business, market - present and future trends

- After five new generations of satellites, they reach financially the break-even point - there needs to be a change - a shift of the break-even point to an earlier stage

Future trends concerning:

Applications

- Applications which will influence the market in the future: agriculture, urban planning, change of telecommunications systems

Technical issues

- New techniques and methods to build and integrate payloads
- Increase resolution

Business, market

- Present trends are towards cutting costs, especially the operating costs

Policy

- Policy on archiving: what should be archived and what will be accessible?
- Will there be a monopoly on data distribution?
- How can we ensure that the data will be secure, and not a danger for parts of society
- Get more people to share the cake, and increase the cake
- Crucial commercialization of data in the future

General issues

- In international cooperation, it is more difficult for Africa to succeed than for other countries, because of the lack of education of the people supporting these issues, such as politicians
- Getting to know the user and building up a direct interface of information exchange between the user and the company, which distributes data.

Session 8

Technological Issues

Session Chair:

S. La Pensée, Space Consultant, United Kingdom

Micro- & Nano-technologies : A Challenge on the Way Forward to New Space Markets

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Abstract

The main objective of space activities in the middle to long term it is to realize economies of scale on life cycle costs of space instruments or spacecraft using Microelectromechanical Systems (MEMS). This means the integration of functions, materials, processes and devices of millimeter, submillimeter to micron size, leading to microinstruments and ultralight spacecraft. MEMS technologies offer many advantages : drastic reduction of requirements such as mass, volume and power, impacting directly on spacecraft, tests facilities and launch costs; replacement of several discrete components or devices by microsystems; production in a batch process on mass production lines (low cost levels per unit); high system reliability by built-in design or incorporation of several microsystems levels; and microinstruments with a real improvement of system performance to cost ratio.

There are some limitations to microsystems space applications but some of them have already been solved, such as radiation hardening, single event upset or latch-up tolerances. Miniaturization would result in smaller and lighter spacecraft, which could be near by a "mother" platform, or tiny platforms in constellations, networks or swarms for Earth or planetary missions. MEMS and specific system design studies will lead to more innovative research in space missions and to many spin-off activities and new business opportunities.

1. Introduction

The way ahead, leading to new markets in the space area and beyond , is via MEMS (Micro Electro Mechanical Systems) and MAMS (Modular And Multifunctional Systems) developments that are now possible by processes such as :

- surface machining
- bulk micromachining
- wafer to wafer bonding
- multichip assembly.

Are we steering towards a satellite on a chip ? This may be possible with the introduction of two "seeds", in the USA with the DoD strategically steering programmes (Reference 1) such as the Strategic Defense Initiative and in Japan the consumer market - photography, video, microcomputers and cars where technologies have been made available. Now, a breakthrough is approaching. In the early years of the Space Age, missions were "pushing" technology development; today, we can consider that technologies "pull" new

missions using "non space" initiated developments with the goal of "smaller, faster and cheaper".

In the middle to long term the main objectives are to realize economies of scale on the life cycle costs of space instruments and spacecraft. How? The answer is through a cultural change for a new paradigm with a "system design" leading and widely using Microsystems (MEMS and MAMS).

2. The possibilities of MEMS and MAMS

MEMS and MAMS work by "scaling " from large to small space systems where applicable. Any reduction in spacecraft platform and/or payload mass, volume or power requirements induces a significant effect with scale factor and cost reduction. Considering the U.S. Air Force & NASA Technology Vision presented at the last COSA Space Workshop (Reference 2), we point out the importance of technological developments consistent with :

- low-cost operations
- spacecraft autonomy
- low-cost and highly capable spacecraft.

This means low mass (< 100 kg), low power (< 100 W), small dimensions (< 1 cubic meter), intelligent flight systems, instruments and sophisticated data processing with :

- self calibration and health monitoring
- autonomous onboard data acquisition scheduling
- autonomous onboard information extraction
- self-positioning.

Conventional weight-power relationships show that, for a 1500 W payload, we have about 120 kg for the harness and 500 connectors, 25 kg for power control units and shunts, 8 kg for converters, 35 kg for batteries (40 Ah - NiCd), and 75 kg for the solar array and its mechanisms. This clearly explains the interest in low power devices.

Microsystems engineering improvements allow complex micromachined structures, multichip assembling, stacking of miniature 2D or 3D intelligent microinstruments, including sensors, data processing, embedded software, data communication, actuators, or command and control functions. MEMS advantages

lead to a drastic reduction of needs, impacting directly on spacecraft design, tests facilities and launch costs (by reducing mass and volume) due to :

- very low power devices; power is limited to only a few mandatory sections
- integration of functions, materials, processes and devices of millimetric, submillimetric to micron sizes - a single microsystem replaces several discrete components
- micro-instruments in situ, and ultralight spacecraft
- improvement of onboard capabilities.

The consequent benefits are:

- production in a batch process, on mass production lines, leading to low cost per unit
- real improvement of "systems performance to cost" ratio per unit
- high system reliability achieved by built-in design or integration of several microsystems.

Micro- and nano-technologies will allow the design and development of more numerous facilities for manned or unmanned Low Earth Orbit missions. Innovative new missions at lower cost, and shorter time scales, will be possible through access to:

- high propellant budget missions
- Earth monitoring networks
- investigation on asteroids
- micro-rovers
- sample and return missions.

Miniaturization results in smaller and lighter spacecraft, in more units close to a "mother" platform or on tiny platforms in constellations, networks or swarms for Earth or planetary missions, and even in virtual instruments.

3. Current MEMS and MAMS activities?

In the USA, based on the experience gained with the Strategic Defense Initiative programmes, the New Millennium Program (NMP) is now pursuing advanced space research and technologies through a powerful network of agencies, government laboratories in connection with prestigious Universities. Global initiatives such as SBIR (Small Business Initiative Research) and STTR

for technology transfer are leading to successful spin-offs and commercialization.

A "technological pipeline" is now operating in order to validate candidate technologies and to produce and transfer mature technologies for the next century.

Figure 1 illustrates the number of organizations involved in MEMS activities (Reference 1).

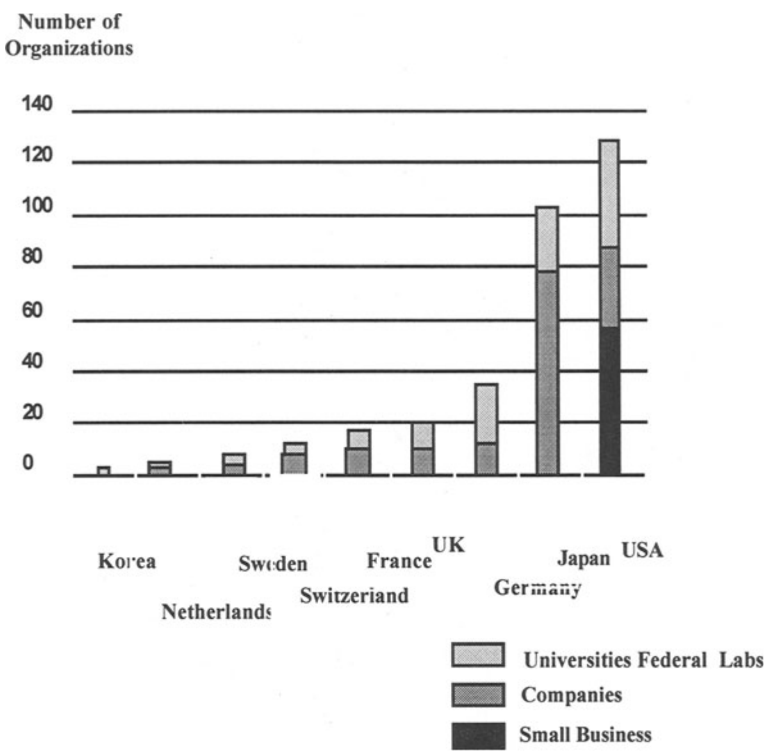

Figure 1: Distribution in MEMS activities

We point out the weak position of Europe and that, in the USA, small business companies are widely involved in MEMS development; in Japan large companies are more involved due to consumers' market needs.

MEMS R&D federal funds for 1995 (References 1 and 3) were as follows:

- US Federal : 35 M$ (NSF: 3 M$, DoD: 30 M$)
- Japan : 30 M$ (MITI)
- Europe : 40 M$ (including France)
- France : 10 M$.

The worldwide global investment for 1995 could be estimated at 370 M$, with a 120 M$ global U.S. investment.

At the U.S. Department of Defence (DoD), continued funding dedicated solely to MEMS is planned, growing to $75 million in FY 1998 (Reference 1) :

- $ 40 million for devices and systems
- $ 10 million for support and access technologies
- $ 25 million for MEMS insertion activities.

These activities are developed independently but coordinated with other federal programs of the same importance.

Figure 2 gives the global future MEMS possibilities, showing a plot of the number of transistors versus the number of mechanical components. This ratio reflects the T/M ratio of integration which indicates the "merging" level of electronic and mechanical elements (References 1 and 4).

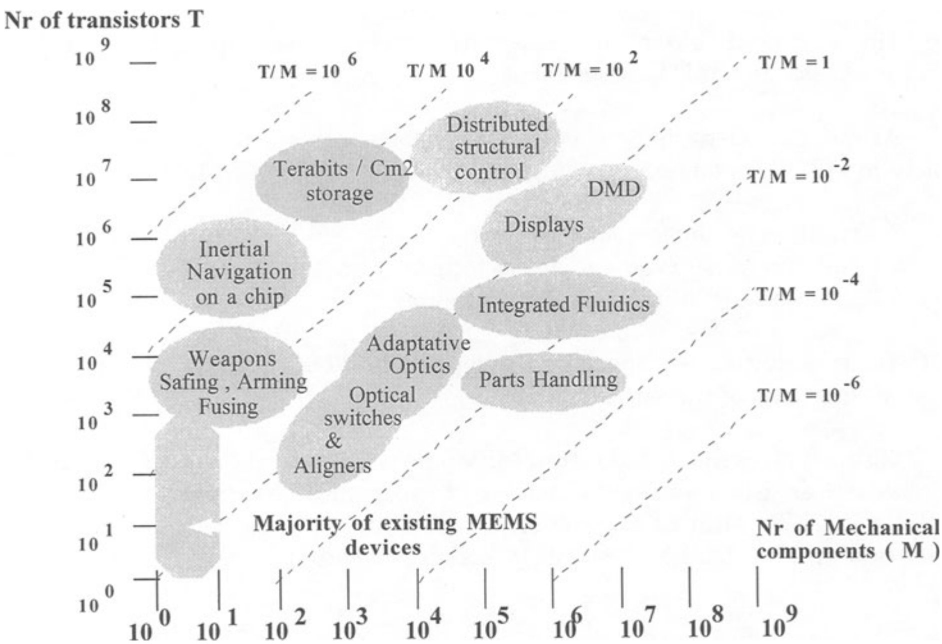

Figure 2 . [T] number of transistors versus [M] number of mechanical components (DMD = Digital Mirror Displays)

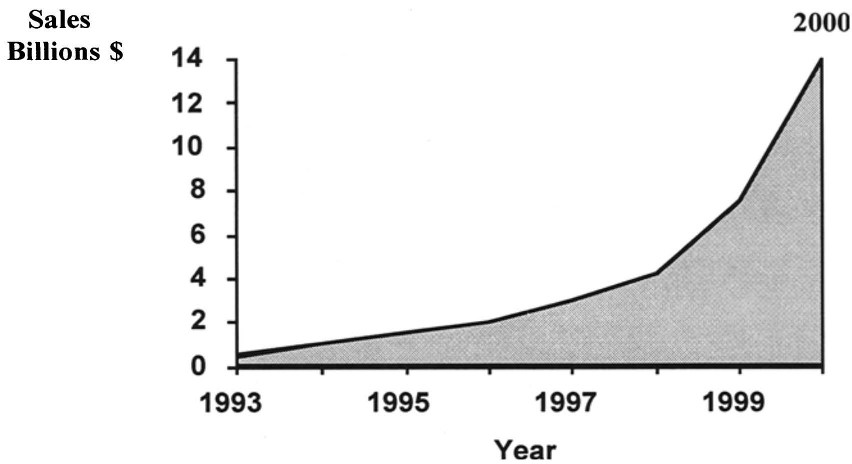

Figure 3. Projected growth of worldwide MEMS market

4. Conclusion

In conclusion, a new market is now growing (see fig 3). In space, the success of MEMS and MAMS is strongly linked to the accomplishment of a change of engineering culture. Whatever happens, Microsystems development will explode, pushed by consumers' market needs.

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Space Technology Transfer as a Source of Innovations

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Abstract

The DARA Technology Transfer Programme is presented in detail. It comprises a threefold way to make space technology accessible to the non-space industry. First, promising technologies are identified and by an extensive marketing effort offered to non-space firms. Space industry as the owner of the technology can profit by license agreements or by starting diversifications into a non-space market segment. Second, DARA is funding the developments of technology demonstrators at research institutes as a first step towards targeted industrial cooperations. A Call for Ideas in the summer of 1996 among 190 German institutes resulted in 60 proposals for terrestrial applications of research results and technology developments related to space. This demonstrates clearly the high technological potential of space research which is available to non-space companies to be utilised for innovations. Support by DARA by the direct funding of technological demonstrators considerably improves the basis for industrial cooperations, resulting perhaps in funding of the research by industry, or even encourages researchers to found their own small enterprises and thus to constitute new markets. Third, new technologies are developed for space as well as for terrestrial applications. The developments stemming from the area of micro-electro-mechanical systems (MEMS) can be used in space research as well as for terrestrial applications. This built-in spin-off makes use of R&D very efficiently by coupling financial and intellectual resources from different fields; some examples are presented. Thus space technologies are opened up systematically as a source for market relevant innovations.

1. Introduction

Technology transfer has always been an integral element of space research and development. In recent years space agencies and research institutes adopted a new attitude towards technology transfer. What in former times was always a nuisance to be done by more or less periodically conducted historical studies nowadays has become integrated programme elements. It is no longer appropriate just to list space spin-offs which almost always occurred by accident but to carry out technology transfer in active and systematic ways.

The spin-offs from space research provide a partial answer to those asking for a justification for space research. All space projects primarily have to have sound scientific and political objectives.

In 1994 DARA started a Technology Transfer Programme with the aim to promote and speed up transfers of space technology into non-space applications. DARA`s responsibilities are - understandably- mainly dedicated to space research and space applicable technology developments. Technology transfer serves as an accompanying programme.

2. Technology Transfer: Definition and Objectives

The Deutsche Agentur für Raumfahrtangelegenheiten (DARA) GmbH was founded in 1989 as a governmental agency to :

- draw up and plan the German programme
- manage the space programmes and
- represent German interests internationally, especially towards the European Space Agency (ESA).

Another governmental organisation dealing with aerospace research is the Deutsche Forschungsanstalt für Luft- & Raumfahrt e.V. (DLR). Based on a governmental decision, DARA and DLR will be joined in 1997. Then there will be only one government funded space organisation like, for example, NASA in the USA or CNES in France.

Technology transfer in our working definition means the process of initiating and supporting the "second-use" of a technology in an application different from its original one. Other terms used are "spin-off" or "fall-out".

Technology can be hardware (products, components, parts), software, materials, procedures, test methods, know-how, ideas.

Innovations are improved products or new products enabled by the application of new technologies. In this sense technology transfer can stimulate innovations.

DARA uses 1.8% of its money for funding projects within a technology transfer programme. As general objectives the DARA Technology Transfer Programme intends to:

- give a fresh impetus to technology transfer from space which up-to-now happened only randomly
- draw the attention of space industry to additional uses of their ideas, also in order to stimulate diversifications
- bring space related research institutes closer to market oriented applications and intensify their contacts with industry
- enable small and medium non-space-companies to have an easy access to new know-how
- contribute to the innovative potential of the national economy.

3. The Methods of the DARA Technology Transfer Programme

3.1 Technology Transfer By Systematic Spin-off Marketing

The motives systematically to stimulate spin-offs, i.e. to transfer know-how and technologies into new applications, are manifold. The utilisation of existing new know-how can lead the technology acceptors to new products considerably faster than solely with their own developments. In addition the purchase of innovative technologies, including possibly required adaptations, might be less expensive than complete in-house developments. That is why the access to advanced technology made easy by transfer initiatives improves the competitiveness, especially of SMEs. Technology transfer opens up new markets and sources of income to the technology donors, e.g. by the payment of royalties or possible diversifications.

Within space technology, in particular, there is a high potential. Being a generic technology its developments touch the most different fields of science and technology - no matter if being designed specially for space operation or being adopted from a terrestrial application. The range of space technologies, which are of interest for terrestrial utilisation, extends from hardware components and software processes to test methods. For example, high temperature resistant screws made of ceramic matrix composites, a laser range finder of a minimum size or a method to determine the micro-circulation in blood vessels are now available for their applications on the ground.

To exploit the existing technological potential of space and to utilise it in a market orientated way DARA started its initiative for technology transfer INTRA in 1994 with MST Aerospace GmbH (Cologne) as DARA´s "technology broker". (It is related to the Technology Transfer Programme of ESA.) The spin-off strategy aims for the stimulation of spin-off effects by active marketing. The measures taken differ according to the respective initiator of the transfer process.

On the one hand the transfer of technologies and know-how without an already existing demand is called technology push. Here technologies are identified and assessed on the basis of the industrial market. Not only is the demand being estimated but also the maturity of the technology, the existence of patent rights and adaptation effort are determined. To support a nation-wide marketing, transfer catalogues are compiled which list technology offers in different technological fields like materials and processes, sensors, electronics and optoelectronics. The first edition of the TRANS-catalogue with

more than 60 technologies was distributed in the summer of 1995 to more than 18,000 non-space enterprises. In addition, firms from selected lines of business are addressed directly and contacts to chambers of commerce, acting as multipliers, are exploited. In the meantime the second edition of the TRANS-catalogue has been published. Now more than 110 different technologies are listed in the two catalogues together. The offers are also published in articles or in lectures at symposia. Cooperation forums are organised to give representatives of space firms and non-space firms the opportunity for confidential discussions. An essential cornerstone is presence at the annual Hannover Industry Fair where the transfer initiative and examples of transferable technologies are presented, and many contacts are established.

On the other hand, the technology pull approach searches solutions for technological problems of non-space firms within the space industry. Inquiries will be discussed with space experts using detailed search profiles. Support by multipliers can be helpful. If there is a match between inquiry and offered technical solution, the genuine transfer phase begins. The advisers of MST Aerospace GmbH suggest possible adaptations and establish the contact between space firms and potential technology acceptors; the support addresses technical, economic and legal issues.

The still young DARA initiative has to date led to more than 300 contacts between space and non-space firms. Approximately 2000 inquiries about technical and general information concerning the offered technologies were dealt with. The contacts already resulted in about a dozen successful transfers; others are close.

An example of a successful transfer is the use of a flat heater for high temperature ovens in the dental business. The material of the heating element consists of pyrolytic boron nitrite with a vapour deposited graphite heater. The high temperature heater was developed for the Materials Lab in Spacelab and used successfully for metallurgic experiments during the D2-mission in 1993. The first edition of the TRANS-catalogue attracted the attention of a German consortium from the dental trade which acquired the heaters to develop new casting devices for dentures and inlays.

For an electrophoresis experiment - for the first time onboard the sounding rocket TEXUS 18 in May 1988 - a degassing module was developed to avoid the influence of gas bubbles on the electrophoresis process. The module can be applied to an efficient and fast degassing of flowing liquids as well as for the controlled gassing of liquids. A SME used this module for the first time in a

pharmaceutical facility and tested it with good results. Another interested institution is planning an adaptation for flow injection analysers.

A firm in the New Bundesländer developed a process for the plasmachemical oxidation of light metal surfaces by a spark discharge to coat components for high performance optics for the Russian Mir station and for ESA projects. The layer thickness can be tuned accurately, the absorption and emission coefficients are radiation resistant, and the thermal stability is extremely high. These properties of the new coating process are used by a manufacturer of optical instruments to guarantee the fitting precision of components in different thermal environments.

A capacitive micromechanical sensor for the measurement of accelerations in three dimensions was developed in the mid eighties for the examination of the microgravity conditions on parabolic flights. The sensors were also used to measure the vibration of satellites like Olympus. Based on this sensor type a micromechanical sensor with commercial potential was developed in a collaboration between a space firm and an electronics company for measurements in one dimension, which is applied in sport physiology and medical rehabilitation. The high precision miniaturised sensor analyses the movements of legs and arms.

Taking into account the typical timescales for a technology transfer, i.e. one to two years beginning with the offer of a technology until an exploitation agreement and an additional two to three years until the appearance of a new product on the market, the initiatives of technology transfer prove to be highly successful. Due to the enhanced commitment in Germany a clear increase of spin-offs is to be expected in the coming years. One should, however, not conceal the difficulties. A major obstacle is the reluctance among the space companies to support the technology transfer. The reluctance is not among the technicians and engineers; they would usually like to see their "brain child" acknowledged and applied elsewhere. Their companies are, however, primarily interested in a high return of investment which in most cases is simply not in sight for the transferable technologies. Hopefully the awareness of their underlying public obligation for a turn of investment for taxpayers' money will grow in future. A small amount of the in-house available funds could promote technology transfer considerably. DARA, as a funding agency, assesses the supposed transfer potential in our administrative forms for each new project . This is the first step to create an innovation friendly discipline. Another obstacle to successful transfers is the required modification of the space technologies, in particular if prototypes have to be developed. This applies in principle to all "technology

donors", but first of all to projects with the participation of SMEs, universities and research institutes. Therefore DARA supports the manufacturing of demonstrators at research institutions to foster the turn into market qualified innovations.

3.2 Technology Transfer by the Funding of Technological Developments Based on Ideas from Research Institutes

Many ideas derived from space projects require a decisive impulse in order to be transformed into a market product, namely the proof of their technical realisation. Therefore, DARA gives grants to start the development of technical demonstrators or prototypes. The operational demonstration of an idea formerly existing only on paper opens doors with industrial producers or venture capitalists for product completion.

Technology transfer in this way is carried out in the programme FIRST CHANCE. Here FIRST stands for "Förderung von Ideen aus der Raumfahrt zur Stimulation des Technologietransfers", i.e. funding of ideas from space to stimulate technology transfer. The First Chance Programme creates the basis for an innovative and industrial use of ideas derived from space projects. It aims for direct contacts between research institutions and industrial enterprises. DARA limits these grants to universities and institutes which have no imminent interests nor the means for a further development of their research results into market products. The programme gives ideas a first chance on the path to a product. It might even stimulate researchers to think about founding their own firm.

More than 200 research institutes were contacted in 1996 in a nationwide Call for Ideas. We received about 60 ideas for terrestrial applications. This is a convincing proof of the high transfer potential of space research in general; space scientists do not live in the proverbial ivory tower. The most promising ideas, about 10%, can be funded within the First Chance Programme.

For example, DARA funds the adaptation of mathematical algorithms derived from the data evaluation of the German X-ray satellite ROSAT to diagnose skin cancer. Astrophysical data with a high background noise are analysed using mathematical methods from chaos theory to extract typical ordered structures with high accuracy. These methods are applied to photographic recordings of potentially cancerous parts of the skin and can ease an otherwise tedious analysing process.

A second example is an exerciser of completely new design, originally designed for in-orbit training. In the frame of two ESA studies concerning the physical fitness of long-time astronauts in orbit a new kind of exerciser was proposed. The inadequacy of conventional treadmills, where the natural walking movement is only imperfectly simulated, is avoided by the new Ergometer. The astronaut can walk or jog on a defined plane in all directions without leaving the plane. The user sets step direction, step length and step duration and the Ergometer transports him back with the same velocity. Direction, length and duration of steps do not only provide the data for movement controlled backward transport, but also for the direction and velocity of the intended movement. To define the position of the lower legs or feet, respectively, the above mentioned acceleration sensors are employed. DARA funds the technical realisation of the Ergometer concept which promises a remarkable market potential not only for rehabilitation and physical fitness but also for moving in "virtual realities". Ideas from the First Chance Programme will be included in a new edition of the TRANS-catalogue.

3.3 Technology Transfer by Synergistic Developments

DARA supports technology transfer by sponsoring developments of technologies with an overlapping application potential. Based on the identification and selection of so called "future" technologies, specific projects are carried out which enable the realisation of new types of instruments and components for space. Prototypes or technological demonstrators are produced. These technological developments with "built-in spin-off" enhance synergistically the effort of other national R&D programmes.

Within this frame DARA is funding a number of developments utilising MEMS technology (MEMS, micro-electro-mechanical systems). This technology allows the integration of functions within one miniaturised system. Due to strong financial support in Germany, in other European states and by the European Union Europe has a high quality, relevant manufacturing techniques at its disposal. This know-how is slowly diffusing into space applications. MEMS is one key technology for NASA´s New Millennium Program (NMP) to develop the next generation of lightweight spacecraft for space science and Earth observation.

DARA started some pilot projects to demonstrate the potential of MEMS. One example is a new kind of miniaturised spectrometer for applications in industrial measuring processes as well as in atmospheric spectroscopy. This spectrometer will have considerably improved specifications in relation to the

already commercially available "spectrometer on a chip", although not being quite as small as that. A second example is a biosensor to be applied in the diagnosis of muscle injuries and infarction on Earth as well as in space medicine. The detection principle is based on the excitation of pigments on the surface of an optical fibre sensitive to the concentration of two specific proteins. The concentration ratio indicates if damage to the skeletal muscles or the heart muscle has occurred. The protein can be detected in blood as well as in urine, making the method attractive for a non-invasive diagnosis of the astronaut's physical conditions. On Earth, the application is sports medicine and rehabilitation, in particular for long-stay bedridden patients.

4. Conclusions

A deficit in innovations in Europe is not a problem of lacking scientific creativity but an organisational problem. There is an abundance of ideas produced by R&D, including space research and space technology. It takes the political will actively to foster the exploitation of this intellectual resource in order to create innovations.

DARA faced this challenge and developed measures to stimulate the process of turning ideas into innovations. The first step of every transfer is communication, the spreading of knowledge available. It has to be supported by funding the development of prototypes with seed money. The next steps are up to industry.

The International Space Station : A New Space Market

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Abstract

This paper presents a preliminary analysis on the way the International Space Station (ISS) may be used for technology and science, not on the ways in which space agencies will manage this, but mainly focusing on the interest which industry may show in such a system for its own development. Possible applications are presented to illustrate how new industrial fields may find real interest in supporting space applications for their own technologies. Up to now, man-in-space led to scientific utilization of the microgravity environment; based on a preliminary analysis of possible non-space industry interests, the ways in which this utilization may lead to a new space market are presented. The paper also presents the possible on-board supports to be provided to the payloads which will be accommodated both on-board and off-board the ISS. In particular, the external payload accommodation concept, developed for the ESA, will be presented to show the constraints to be fulfilled by the payload designers and the main services to be provided by the ISS to the external payloads located on Express Pallet.

The paper concludes with a preliminary identification of this forthcoming market showing the major roles to be played by agencies and the space industry.

1. Background

After the Toulouse conference, held in 1995, the International Space Station (ISS) is now becoming a reality. It will provide Europe with permanent access to and a capability to use the space environment. Although the utilisation baseline of the ISS is dedicated to the scientific community, the question of its commercial utilisation has to be addressed.

It seems obvious that a permanent scientific utilisation of the ISS will not lead to an effective optimisation of its possibilities. Thus it has to be clearly stated how the Space Station should be proposed to industry for its own research and development. Besides this question a way has to be found to interest industry in using the ISS. Once these two questions have been answered, the ISS will become an effective new space market.

2. The International Space Station

The ISS is designed to provide a working environment to science in space. It can accommodate payloads both inside the station and outside, on dedicated areas located on the truss. The modules provide a laboratory-like environment with all the resources needed to install and operate scientific payloads. Some payloads will be the large versatile facilities developed by the European Space Agency (ESA) to satisfy the different scientific fields:

- life sciences, with the BIOLAB,
- materials sciences, with the MSL (Material Sciences Laboratory),
- fluid sciences with the FSL (Fluid Sciences Laboratory).

The payloads located in the modules have to follow safety rules in order to be accepted in the manned flight environment. The external locations meet a generic concept of accommodation which specifies the mechanical, thermal, and operational interfaces of the payloads. This approach is quite different from that selected for the internal utilisation of the ISS. A concept of Express Pallet has been defined:

- the Express Pallet is a mechanical structure on which up to six Express Pallet Adapters (about 1m x 1m) are installed.
- the Express Pallet Adapter (EPA) accommodating the user payloads has to follow the standard rules for hardware in space.
- the EPA provides the user with access to standard resources (electrical power, data handling support, ...) to ease the installation of the payloads.

Throughout the life of the ISS the EPAs are changed according to the EPA user's requirements.

This Express Pallet concept is a very flexible one which, due to the different locations on the truss, provides support to:

- microgravity experiments,
- Earth and solar observations,
- technological experiments.

ESA is responsible for the utilisation of 3 Express Pallet Adapters (for a preliminary 3 year period), relying on the European scientific community to define their contents.

3. Application Fields

Up to now, industry has not clearly stated its own research needs aboard the ISS.

The space industry may be directly interested in using the ISS to prepare, validate and demonstrate their technologies: space conditions offered by the ISS may be an effective testbench to validate new technologies applicable to

equipment (sensors, hardware, ...) or to assess the feasibility of concepts which cannot be proven on Earth without complex test facilities.

The non-space industry may use the space environment to support specific industrial research in various domains. For instance, some industries may be interested in the particular capability of handling specific processes in a way which is not accessible on Earth. The ISS may be an opportunity to achieve results allowing them to understand and improve on-ground technologies.

Industry will undoubtedly be concerned by:

- the overall duration between the industry request and the mission results,
- the overall cost, including all the development phases,
- the legal aspects and intellectual property rights.

4. ISS Utilisation : The Main Issues

For industry to use the ISS, attention must be paid to the following five issues.

Speeding up the process. The time between experiment selection and the flight needs to be decreased. This requires the establishment of clear rules for payload (PL) selection in order to guarantee and protect industry interests, and to support the PL manufacturing steps by establishing adapted design rules and standards and by proposing standardised equipment to the developers. They will be charged with the recurrent costs but will not have to study specific and space-qualified hardware for standard parts such as the power supply. Regular access to the ISS needs to be guaranteed in order have a short planning cycle.

Reducing the cost. Space utilisation is very expensive; the costs need to be decreased by developing standard equipment, by reviewing the Space Qualification Process for Technology PLs, and by adapting this to the real needs. The launch and operations costs have to be shared between the Agency and industry in a clearly agreed ratio.

Using the results. Some part of the costs (e.g. launch) will be taken into account by the Agency; however, the results have to remain the property of industry. This means the establishment of Rules and Laws to define ISS access, and the management of ISS access to non-ESA members companies.

ESA's role. The responsibility of the Agency, as ISS access supplier, must be to create and maintain the conditions for access to the ISS :

- Logistics frame
- Contractual and Legal Frames
- Effective Pricing Policy.

Industry's role. Industry must present a consistent funding plan, to have a credible project. Industry has to demonstrate that space is a key factor for reaching a technological goal in a real Business Plan.

5. ISS, a New Space Market

The previous section introduced the main issues to be clarified, preparing the ISS for utilisation by new classes of users. Then, the possible market has to be analysed according to:

- support to be provided for ISS utilisation,
- utilisation domain.

Up to now, the utilisation of manned space flights has always been dedicated to basic scientific researches conducted by scientific laboratories on behalf of the Agency. This situation is mainly due to the fact that the number of possible missions was limited and their duration too. This situation led to a very precise selection of the experiments to be flown. The ISS will make possible the permanent utilisation of space, with a quick access and possible retrieval of the experiments.

For instance, in the domain of alloy analysis, it seems that microgravity conditions are quite favourable for the generation of a specific alloy which cannot be made on ground. Using the ISS will mean the capability to prepare, according to precise specifications, samples processed in the Material Sciences Laboratory. Due to the regular servicing of the ISS, it will become possible several times a year to have access to the ISS for MSL utilisation.

The emerging space market will require:

- support to space access, in order to provide the users with the different components which are necessary to accommodate their payloads. In particular, the ISS makes possible the accommodation of payloads shared by a wide set of users; for instance the scientific community proposes to

install on the ISS a set of atomic clocks which may be used by different users (navigation, time synchronisation, ...) in a "pay for service" approach.

- support during all mission steps:

  - operations preparation,
  - launch,
  - operations execution,
  - retrieval and post-mission.

6. Conclusion

Besides the traditional space markets (telecommunications, Earth observations, ...) the ISS is a new market due to the capability to access a permanent platform which will support a wide variety of scientific opportunities and services. The future role of the ISS as a new market needs to be thoroughly analysed. Whatever the results will be, this market will only emerge if space agencies develop the frame in which this access is timely and effective.

Report on Panel Discussion 8

Technological Issues

Panel Discussion:

J. Benoit

S. La Pensee

G. Kraft

J. Tailhades

S. La Pensee considered that Technology Transfer from an innovative perspective can be prescriptive; for industry it is the response to the customer, whereas for a university it is the development of new technology.

J. Benoit responded by introducing NASA's New Millennium Program, NMP, which has the purpose of building satellites using cutting edge technology. Small innovative business enterprises combine new technologies from universities and small industries. The main concern is the technology trap, which develops quickly: the speed at which computer technology is developing is remarkable.

G. Kraft considered that there is a division between fundamental science and R&D; they should not be confused. Quality should be measured by colleagues, but this should not set the criteria. There is great potential for MEMS, but there is nothing like the NMP in Europe.

Issues arising from questions:

There is a long time between the development of new technologies and the implementation of these new technologies. With regard to funding, companies that would be interested in using new technologies should invest in their development. For potential "spin-off" developments, PhD students are encouraged, through sponsorship, to spend an extra year to develop their ideas.

Conclusion:

There are two different markets: agencies and businesses.

S. La Pensee concluded the discussion by defining a customer :

- he has a problem to solve,
- money to solve the problem, and
- a willingness to solve the problem.

All three of these characteristics are needed for the customer to exist in reality.

Poster Papers

New Space Markets: Understanding the Security Rationale

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Abstract

The rationale for space activities has changed since the end of the Cold War. There are now opportunities for both cooperation and commercialisation. The military rationale for space observations and technologies is changing, but global security is as important to all as ever it was. The concept of comprehensive security - not only military, but also economic, ecological and sociological - is introduced.

1. Introduction

Long before the end of the Cold War, the issue of the non-defense rationale for space activities attracted the attention of space policy studies in the major space-faring nations. It was understood that space activities provide services that are vitally important for the well-being of a state - from the early warning of attack to weather forecasts. Space technology formed the basis for the strategic nuclear parity that determined the pattern of world security for many years. However, this nuclear parity led to the understanding that a nuclear war is improbable, if not impossible, and thus diminished the importance of space technology for military security. The world economic crisis accompanied by the breakup of the Soviet Union led to tremendous cuts in space budgets. With no clear enemy to defeat and with no race to win for the sake of national pride and prestige, national space programs lost their priority status (Reference 1). Two solutions were proposed to the problem: cooperation and commercialisation.

1.1 Cooperation

The political importance of space activities negatively affects the possibility of decreasing the financial burden through international cooperation. Traditionally, international cooperation occurred at governmental level and served the purposes of politics or science (Reference 2). Nowadays, cooperation often implies direct or indirect economic benefits, and countries tend to limit cooperation to prevent a possible competitor from gaining a technological or even a military advantage (Reference 3).

1.2 Commercialisation

The commercialisation of space activities allows government expenditures on space to be reduced by attracting private sector funds. The proponents of that approach give the example of highly profitable commercial space ventures (Reference 4). Sustainable growth in the demand for space goods and services must also attract private investors (Reference 5). However, space commercialisation is possible either in the field where space plays a supplementary role to the existing market (communications) or in the field where the technology was developed with govermental money and then transferred to the private sector (launchers, remote sensing, navigational systems). Large space ventures are either subsidised (for example Société Européenne de Satellites - Astra) or directly controlled by government (Intelsat, Inmarsat, etc.). Attempts to create a fully independent private enterprise operating a comparatively large space segment have, to date, been unsuccessful (Reference 6). The absence of a clear legal framework for space activities both at national and international levels makes investment in space activities highly risky (Reference 7). This risk is also increased by the sensitivity of space policy to the political environment which makes the availability of public funds uncertain (Reference 8). Attempts were made to create a so-called governmental space market, that is a market where the government is the direct buyer (user) of commercial space services using existing defense-contracting patterns. This market is a branch of the vast defense (weapon) market, yet lacking the military security rationale characteristic of the defense market. The negative funding situation is worsened by the fact that space programs always deal with the development of high technologies that cannot be quickly evaluated and priced (Reference 9).

2. Value of Space Activities

Modern industrial societies are extremely dependent on the space technology that is imbedded in the system of social links in many ways, starting from satellite TV and weather forecasts to global change research and high technology spin-offs. The situation is now in deadlock: on the one hand humanity cannot afford to quit space programs because that will lead to lags in many fields of technology and on the other hand space programs at the Cold War level are now out of the financial reach of many countries. For the space community, it is very difficult to justify the allocation of scarce public funds to space programs. Space protagonists must either find a new criterion to evaluate the effectiveness of the budget or put forward an understandable rationale.

2.1 Military Rationale for Space Activities

The defense field demonstrates visible and assessable benefits of space technology. The Gulf War showed the ability of space means to increase the effectivemess of the armed forces. This effectiveness expressed as the reduced number of sorties and smaller amounts of fuel burned due to precise space navigation and reconnaissance is easy to evaluate and can be used to justify the budget allocation. In the non-defense sector, attempts have been made to find quantifiable criteria to evaluate the benefits of space programs (Reference 10). The biggest problem in these studies was to find a universal criterion. These studies were performed by economists who tried to use economic methods to evaluate the indirect benefits of space activities.

Thus it is difficult to justify the expenditures for the space activities within existing economic or political paradigms, because these paradigms still derive from the Cold War situation. Now, humankind enters the painful process of paradigm change, which is most vividly identifiable in the case of the security paradigm.

At the end of the 1980's the nuclear opposition of the superpowers come to a dead-end: nuclear arms gradually started to lose their combat importance, especially after the failure to create a reliable missile-defence system and the enhancement of "deep strike conventional capabilities" (Reference 11). The partition of the USSR changed the global security structure. Though the possibility of a massive ground assault or deliberate nuclear attack diminished, the US unilateral claim for global leadership was seriously questioned at the regional level (Reference 12). Moreover, the global community failed to prevent the development of regional instabilities into bloody ethnic wars (Reference 13). That proved the inability of existing conflict-mitigating institutions to compensate for the political instability and brought the need to create a new security framework (Reference 14). Besides such military instability the worsening economic and ecological situation in the world stimulated attention to the long neglected issues of national security (Reference 15).

The modern complicated security context witnessed many approaches to a classification of the new security threats (Reference 16). All of them share an understanding of the following: (1) the end of the Cold War did not make the world more stable: (2) the emergence of the global economy leads to growing competition and to the interdependence of the countries, making it possible to use new "weapons" to decrease the competitiveness of the adversary; (3)

activities by individual nations often have a global impact and may change the world ecological balance; (4) existing national and international political and economic institutions were unprepared for the new global challenges; and (5) all global security issues are interrelated and cannot be considered in isolation from each other.

Another important feature of the modern security environment is that new threats cannot be mitigated at the national level. Ecological problems, arms proliferation, transnational crime and terrorism demand close cooperation at the regional and global levels. Moreover, international communications networks and transparent state borders made it impossible for an individual state to control effectively the information, cash and goods flowing into and out of its territory, thus creating new security threats (Reference 17). The situation is especially problematic in view of regional instabilities and ethnic tensions.

2.2 Comprehensive Security

The modern security environment is also determined by the interdependence of different security factors; for example, ecological problems may cause conflict that may lead to war (Reference 18). That interdependence leads to the emergence of what may be called the comprehensive security concept, security activities aimed at the mitigation of any threats - political, military, economic, etc. - at any level - national, regional or global (Reference 19). The uncertain security environment put forward new demands on national decision mechanisms, decreasing the time available for the analysis of the global situation and increasing the probability of mismanagement (Reference 20). Thus, the security situation looks very favorable for space activities. The demand for a quick global view of security problems can best be met using space technology.

It should, however, be mentioned that an understanding of today's political situation in terms of comprehensive security is not common. For example, in Europe people understand security as a purely military activity and prefer to address other hazards as "problems" - ecological problems, natural disaster problems, etc.. Thus, it seems reasonable to use the paradigm of comprehensive security for the evaluation of the benefits of space prorgams. This approach can combine an understanding of the place of the space program in the system of socio-economic interactions and quasi-quantifiable sociological criteria to evaluate the effectiveness of space activities.

First, an evaluation of the space program in terms of the comprehensive security paradigm can show the importance of the space program for a country's well-being: if a country's technological level decreases as a result of space expenditure cuts and then becomes dependable on another country's technology, that inevitably leads to political dependence and to reduced economic competitiveness, and this is a pure national security issue. Secondly, the comprehensive security concept implies the use of sociological instruments that can "tune" the space program to the needs of a country and thus provide another understandable and clear rationale for space activities. Moreover, the aerospace industry has good experience in security related studies that can become the basis for a new approach to space programs. Thirdly, the comprehensive security concept may provide criteria for the evaluation of those space services that proved to be difficult to assess in purely economic market terms, because of their risky character and heavy governmental subsidies. Fourthly, the security rationale is very important for any scientific or technological endeavor because the budget of security-related programs is limited, usually by a nation's awareness of a hazard or a threat and that nation's economic situation. This awareness is measurable by existing sociological techniques, and can provide feedback for the planning of space activities.

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In Step with the World - Entrepreneurial Approach to New Space Markets

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Abstract

This paper highlights the strength of a deregulated market , placing the emphasis on space and space-related businesses. An emerging entrepreneurial model has taken shape on account of efforts put in independently by various space agencies. Applications of space and space-related technologies in daily life and their roles in business activities are introduced.

The emerging entrepreneurial roles are seen as two-fold: government as an entrepreneur, and the vibrant private sector.

1. Deregulation

It is very rare that an opportune time comes that favours a large mass of people. From the realms of prolonged controls to the very thinking of de-control itself is a step towards openness, an attempt to bring about change, opening up new vistas.

This is what has happened in the liberalised telecommunications policy in India. This has given free hands to enterprising entrepreneurs to re-align themselves with the changing winds. There is a surge of activities that has sprung up from within the entrepreneurial self of individuals. Creative minds, coupled with sharp business acumen and a sense of direction, have plunged into exploring and exploiting the new markets and opportunities on their doorsteps.

2. Telecommunications Opportunities

Access to "space" by private operators has prompted entrepreneurs to venture into a wide scope of businesses. Yesterday's data processing managers are now trying to qualify themselves as Information Technology and Telecommunications experts. With the connectivity through space now becoming handy for anyone, the scope of reaching from anywhere to anywhere via voice, data and video has increased tremendously. User organisations that relied on conventional traffic links have now become "space" hungry. More and more user organisations are themselves becoming enlightened as to the adaptibility of this new medium now available to them, and are adopting it.

There is a spurt in the activities of "space facility providers" - a new breed of service providers, systems integrators, systems consultants. An atmosphere of synergy is prevelant throughout. Alliances are being formed between groups, small and big, to use the other's strengths to serve the customer better. There is now a thin line between these groups - those providing, say, VSAT hardware, and those that support LAN products, internetworking hardware, systems software, and video-conferencing equipment. Experts that used to work in the field activities of large Earth stations are now extending their reach to provide their skills and expertise in VSAT antenna site clearance, installation, and alignment. There is a fair degree of technology-shopping overseas for VSAT equipment providers, making new contacts with technology groups and attending space-related seminars, symposia and exhibitions.

The Department of Space of the Government of India is one of the prime movers to pursue the openness approach to new space markets. A lot of brainstorming, homework and reorganisation exercises have been undertaken concerned with tapping and addressing the vast global markets in the space arena. Their success stories are plenty and the growth-rate is phenomenal. Their entrepreneurship has put India on the global space map. A vibrant private sector can benefit, and improve the lives of all.

Global Operations for the Next Century

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Abstract

This paper describes a New Century Architecture (NCA) representing a typical future operational Satellite and Telecommunications (SAT) system using where possible vendor independent, shareware and Commercial-Off-The-Shelf (COTS) systems. The concept is illustrated using the Satellite Tool Kit suite of COTS software analysis tools.

1. Trends

The Internet is fundamentally altering the organizational structures of our institutions and the living conditions of our society. International data communications will remain the fastest growing parts of business traffic. Satellite and Telecommunications (SAT) demand will force a significant shift towards end-to-end cost effectiveness following similar trends in telecommunications. Developers will rethink and re-engineer basic SAT processes with the goal of reducing overall program expenditures. Five business "factors" will shape SAT development: Corporate Networking, Satellite Backbones, Privatization, The PC Revolution and Data Communications Growth. A growing emphasis will be placed on using SAT networks to connect corporate databases, build links to fixed and mobile customers, suppliers and so on. More and more corporate and government organizations will take responsibility for their own SAT networks. Data communications have been growing at 40% per year.

SAT users and working needs will set the requirements, which are not adequately fulfilled today. SAT systems must provide functions in a manner which the users expect, when needed, and at a cost which users consider reasonable. SAT based information systems including sensor monitoring, data collection, and analysis already have produced major impacts upon operating environments. Developing global interfaces to accommodate this constantly growing demand of unpredictable traffic volume is a primary New Century Architecture (NCA) design goal. NCA operational structures must be insensitive to traffic characteristics; they must provide rapid and convenient rearrangement and reprocessing facilities to maintain performance standards during periods of growth or change.

2. NCA Design Techniques, the COTS Approach

NCA development must have a coherence between Design, Development and Operational Phases. Employing NCA technology, tools and methods provides an opportunity to bring about a condensed life cycle resulting in reduced cost and time without sacrificing quality. Achieving this objective requires NCA building blocks to be small dedicated modules. Each module contains a high degree of regularity among functions, implying an ability to share logic among other modules. Cost effectiveness is achieved by using low-cost COTS components coupled with an ability to install additional capacity, when required, in small increments. Building a SAT mission can be accomplished using a set of integrated COTS tools. To illustrate the concept, we will use three separate COTS tools supplied by Analytical Graphics, Inc: Satellite Tool Kit (STK), Satellite Tool Kit Programmers Library (STK/PL), and Satellite Tool Kit Visualization Option (STK/VO). The interconnection of STK to STK/VO provides the user with a three dimensional viewing capability that provides mission and orbit analysts with an intuitive view of complex SAT mission and orbit geometry, by displaying realistic 3D views of spacecraft, sensor projections and orbit trajectories. Interconnection of STK/PL provides the user with a set of tools that contain high level Astrodynamics, Graphics and User Interface routines and low level functions such as list and stack management, database and parsing routines. Interconnection to user applications can be accomplished by adding an Inter Process Communications Module (IPC) enabling the user to work with STK in a client-server environment. The approach taken is to integrate STK tools into a resource sharing computer network under a single monitor and file system and make all STK tools uniformly accessible to designers, programmers, project managers, and operational personnel. To summarize, COTS systems coupled with technological advances in storage/processing logic and interconnecting structures used in an NCA system will reduce systems costs dramatically. NCA using COTS will attract a large community of users. Also users of existing systems will see the benefits of adding functions by installing COTS systems.

3. Conclusions

Systems taking advantage of the opportunities provided by COTS software structures will become sufficiently important collectively to comprise a technical advance to operations planning. User needs for operational flexibility, allowing continuing adjustment to existing systems, will continue to grow. An important contribution to this process is due to the technical and cost benefits of using COTS software.

Constellation Design and Development for Efficient Manufacture and Operation

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Abstract

The next few years will witness the development of the first satellite constellations for global communications. The commercial success of these seems likely to ensure the development of a number of further constellations, not only for communications, but also navigation and monitoring purposes, and will rely heavily on the efficient design, manufacture and operation of both the user and space segments. Previously, user terminals were mass-produced and the satellites were hand-crafted. However, for the development of cost-effective constellations new manufacturing methods will need to be applied to the space segment as well. Volume production of satellites has already started (albeit in small numbers) with Iridium and Globalstar. These have borrowed production concepts from the automobile industry, as well as attempting to embrace methodologies such as concurrent engineering for cost efficient manufacture. To develop a truly low cost constellation, development methodologies must go further and embrace the full range of Design for X tools. These tools include design for reliability, design for serviceability, design for modularity and design for quality, all of which must be applied to the entire system. In addition, the trade-off analysis performed when developing satellite constellations and constellation satellites must consider the level of acceptable risk, which should be treated as a resource to ensure maximum benefit. Finally, a design for life cycle strategy can lead to activity-based costing and indicate the benefits to be gained from these new approaches.

1. Satellite Constellations

In the early 1990's, a stream of proposals for low Earth orbit communications satellite constellations appeared; for the first time, many identical satellites were required. The size of the constellations ranged from 12 for the ICO system, through to 924 for Teledesic in its fullest form (Reference 1). Whilst industry has experience in the serial production of satellites (Reference 2), substantial redesign work takes place between successive missions to tailor each spacecraft to its specific role. With the advent of constellation satellites volume production techniques can now be applied.

2. Volume Production Satellite Development

For complex engineering systems, such as the development of a satellite, typically 70% of the cost of the system is fixed by the end of the conceptual design phase. Thus, careful conceptual definition and initial design followed by a structured demonstration and validation programme will be instrumental in reducing the total design, manufacture, implementation and operating costs to a minimum. The most significant considerations are:

- Design for X (Reference 3): Design for X techniques (such as design for manufacturability, assembly, integration, testability and operatability) and tools can be used in a number of areas during the development of a satellite and its associated ground-based technologies. An expansion of the suggested design for X tools, provided in Reference 4, ranges from specific factors such as a minimisation of the parts count to ease assembly, through to the adoption of an end-of-line plug-in-and-test approach for testing and cross linking, and prioritisation of satellite telemetric data to reduce ground station numbers and personnel.
- Risk as a Resource: A greater acceptance of commercial grade components brings rewards in the guise of reduced costs. Whilst many spacecraft are still built with redundant or backup systems, in many proposed constellations it will be possible to reconfigure the constellation slightly to cover, either temporarily or permanently, for an inoperable satellite. System and constellation level analysis needs to be performed to maximise the cost benefit which results from the extra advantage, in terms of risk.
- Design for Life Cycle: It is necessary to predict the constellation's cost, including all aspects of its development, manufacture, launch and operation, early in the design process. A model, currently under development, will help to predict system level costs for a constellation during phase A studies, using an activity-based costing approach to evaluate the effect of modifications or new design methodologies.

3. Conclusions

New design influences, which to date have only played minor roles in satellite manufacture, will become prominent in the development of volume production satellites. The new approach necessary for constellation development will call upon design for X tools and methodologies, greater reliance on trade-off analysis to predict cost saving measures, and acceptance of a greater risk to ensure maximum benefit in constellation development.

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The Grand-Bassin Case Study: A Step In Sustainable Development

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Abstract

In La Réunion, a point-to-point link transferring energy via a 2.45 GHz microwave beam to a small isolated mountain village (Grand-Bassin) was demonstrated. Technical, financial and environmental aspects of the Grand-Bassin case study, which is commercially viable, are considered. Such a link, carrying power, would be an alternative to conventional power lines, with far better aesthetic integration into the natural environment. It must comply strictly to safety standards in order to be accepted by the public, and demonstrate that no health or environmental damage occurs.

A minimum of 20% global efficiency has to be reached by the system to be competitive with photovoltaic techniques in terms of running costs, and this system's efficiency should be well above that minimum. More studies have to be pursued, more specifically on microwave sources and rectifiers to reach the highest expected performance and to make the system portable so that it can deliver clean and sustainable energy to other isolated sites in need of electrical power.

1. A Microwave Link for Electrical Power Transmission

Our laboratory has undertaken, as a first step to an actual working Solar Power Satellite (SPS) system, a case study whose aim was to evaluate every aspect of a Wireless Power Transportation (WPT) system to transport energy from point A to point B, in order to deliver 10 kW of electrical power via a microwave beam to a small isolated village of La Réunion, called Grand-Bassin, where there are four tourist lodges. The power density near the receiving antennas, arranged as a pergola, does not exceed 10 mW/cm^2. With an efficiency of more than 20%, this system would be advantageous over photovoltaic systems in terms of installation and running costs. We can achieve greater efficiencies, making this system economically viable.

In parallel to our study, we have made many demonstrations of small WPT systems to the population, trying to keep them informed of what this technology is and what the risks are compared to known technologies. We believe that technology acceptance is not just a mind concept but could become a barrier to technology applications and the development of markets.

A prototype version of the system is being built at the moment. This project is made in close collaboration with local industries in order to transfer the

technology to private sector firms. This makes them ready for new markets and, at the same time, should allow them to show their know-how to the world.

2. Potential of Wireless Power Transmission

Unfortunately, there are also places that men cannot access anymore, such as contaminated or toxic areas, where work must be done by robots. Robots need energy to work. WPT systems can deliver electricity to the robot, speeding up its work by avoiding returns of the robot for either fuel or battery recharging.

In order for such applications to be developed successfully, industrialists of the private sector have to consider being involved in research and development of a system originally thought of as space equipment; there are useful applications on the ground well before they are used in space. There is a developing new market, which helps nations to find a clean and sustainable solution to their energy problems. Such nations' administration policies need to help align market forces and technology development, with the goal of sustainable development, that is to say developments that meet the needs of today while giving the ability for future generations to meet their own needs. WPT, as a key technology to SPS systems that could help deliver clean and sustainable energy in the future, has immediate beneficial applications and might then be an excellent candidate for sustainable development, provided that the associated risks can be proven to be low both for humans and for the natural environment.

3. Conclusion

We have shown that WPT technologies can lead to short term applications that could develop new markets on the ground, well before being used as a key technology in SPS systems in space. In that sense, it is a sustainable technology that nations should support in terms of research and development and when defining their policy for sustainable development. This policy for sustainable development should help align market forces and technology development, giving rise to immediate and significant benefits to firms involved in WPT programs. It also benefits consumers, 21st century people who are forced to live in a 19th century way because of the lack of electricity.

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A Brief Account of the General Organization of Remote Sensing (GORS) in Syria and its Activities

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Abstract
GORS was constituted in Syria in February 1986. Located in Damascus, GORS cooperates with some government bodies, all Arab countries, foreign countries, and international bodies. GORS carries out studies and projects on remote sensing applications to geology, hydrology, hydrogeology, agriculture, urban planning, environment, meteorology, and archeology, by using LANDSAT and SPOT images. GORS publishes space atlases of Syria, glossaries of remote sensing terminology, and journals of remote sensing. Further, GORS organises courses and an international symposium.

1. Introduction

The General Organization of Remote Sensing (GORS) was constituted in Syria, in February 1986, in accordance with the legislative Decree No. /8/. It has thus replaced the National Remote Sensing Center, which was established in the Syrian Arab Republic through an ad hoc Steering Committe in 1981. The organisation is located in the Sabbora area (about 17 km West of Damascus).

2. Cooperation

GORS cooperates with the following govermental bodies in Syria:

- Ministry of Higher Education
- General Establishment of Surveying
- General Directorate of Meteorology
- Universities
- Ministry of Irrigation
- Minstry of Agriculture
- Ministry of Petroleum
- Ministry of Environment
- Ministry of Housing and Public Utilities.

GORS cooperates with all Arab countries and the Arab League. GORS is seeking to establish an Arab Space Agency. GORS also cooperates with the following foreign countries and international bodies: Germany, France, India, The Netherlands, USA, Austria, Italy, Russia, Japan, Poland, England, Canada, Thailand, Cyprus, Pakistan, Turkey and The United Nations.

3. Training

GORS conducts an annual training course for new staff members.

GORS has organized the following symposia in Damascus:

- The First Regional Symposium on *The Role of Remote Sensing in Supporting the Economy of Developing Countries*, held on 5 - 7 March 1990.
- The Second Regional Symposium on *Remote Sensing as a Tool for Natural Resource Management*, held on 9 - 12 December 1991.
- The Third Regional Symposium on *The Integration of Remote Sensing and Geographic Information Systems*, held on 23 -26 November 1992.
- The Fourth International Symposium on *The Application of Remote Sensing for Desertification Monitoring and Control*, held on 16 - 19 December 1993.
- The Fifth International Symposium on *The Applications of Remote Sensing and GIS in Water Resources Management*, held on 31 October - 3 November 1994.
- The Sixth International Symposium on *The Role of Remote Sensing and the New Systems in Supporting the Integrated Development*, held on 29 October - 2 November 1995, and the *First Arab Conference for Remote Sensing and Space Research.*
- The Seventh International Symposium on *The Application of Remote Sensing and Assisting Systems to Comprehensive Environmental Planning and Archeological Detection*, held on 25 - 28 November 1996.

4. Projects, Studies and Publications

GORS distributes remote sensing data and carries out projects on remote sensing applications to geology, hydrology, hydrogeology, agriculture, environment, urban planning, archeology, and meteorology for Syria.

GORS has issued the following publications:

- Space Atlas of Syria
- Glossary of Remote Sensing Terminology
- Journal of Remote Sensing.

Legal and Regulatory Aspects of the Future International Global Navigation Satellite System

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Abstract

The future air navigation system using satellites which is proposed by the International Civil Aviation Organization (ICAO), also called the Global Navigation Satellite System (GNSS), is bound to revolutionize many aspects of our daily life. GNSS applications are such that a New Space Market is unfolding in front of us; some legal and regulatory aspects are considered here briefly.

1. The Main Legal Features of the ICAO Future Air Navigation System

Several main characteristics of the future ICAO GNSS are:

- Universal accessibility. Global positioning of aircraft will be available on a continuous and non-discriminatory basis to all air navigation users.
- Temporary free of charge access. Services will be available free of charge for a certain duration of time.
- Full liability of the signal provider. The GNSS signal provider is responsible and liable for the integrity, reliability and continuity of the signals to meet the needs of air navigation, as well as their increase.
- Service provider transparency. Full disclosure of information to ICAO is specified in order to abide with the Chicago Convention provisions.
- Preservation of sovereignty, including responsibility of contracting states. The sovereign authority of states over their airspace is unaffected.
- Cost recovery. The ICAO Council stated that reasonable cost allocation between users should be implemented, together with any recovery of costs incurred in accordance with the Chicago Convention, especially Document 9082 on Charges for Airports and Air Navigation Services.

2. Issues Raised by Provision of GNSS Services Under Space Law

In the short term, the future GNSS will be provided by the US and/or Russia, and/or at least one international organization - INMARSAT - through its ICO Global Communications affiliate. What is at stake in terms of liability is the liability that someone may incur in case an airplane should receive a wrong or false satellite signal which causes an accident.

With its already operating military Global Positioning System (GPS), it is clear that the US will have the lion's share in the management of the new system. This will inevitably lead to involving the liability of at least five different types of respondents: the US government in case of malfunction causing any kind of damage, and the non-US government bodies (i.e. the US and non-US manufacturers of satellites or related ground GPS and non-GPS equipment); non-governmental bodies that may one day control the future GNSS; any other national authority which may be involved in the functioning of the positioning system and be held liable under its acceptance of being involved in the partial operating of the system; and the aircraft itself and its crew, (as in any other air navigation situation).

The US GPS, the main component of the future GNSS system, is the only system that is fully operational. The Russian GLONASS system has partly been placed on orbit and INMARSAT's ICO Global navigational system is not yet operational.

Article XXII of the 1972 Liability Convention specifically includes "any intergovernmental organization which conducts space activities if the organization declares its acceptance of the rights and obligations provided for in this Convention". Since several of INMARSAT's member states are signatories of the major space treaties, the 1972 Liability Convention applies to its satellite communications activities within GNSS. The type of liability between the organization and its member states will be "jointly and severally", provided that the claim is presented first to the organization. If, after a six month period, the organization has not paid any agreed sum, the claimant may invoke the liability of the member states. In the case of the GLONASS part of GNSS, as in the situation when any non-US satellite system participates to GNSS, the question is raised as to the identification of the faulty piece of equipment which may have caused the incident creating the damage. If the GLONASS segment of GNSS is responsible for the damage, then the liability issue will have to be addressed in reference to Russian law. The treatment of this issue under US law may serve as a guide to answer its Russian equivalent. The yet unresolved liability issue in case of damage created by any faulty part of the whole system adds to uncertainties surrounding ICAO's GNSS concept.

Session 9

Symposium Conclusions: The Way Forward

Session Chair:

E. Triana, Advisor Hors Classe, DG XIII, European Commission

Report on Panel Discussion 9

Symposium Conclusions: The Way Forward

According to E. Triana:

Strategic decisions in the near future in areas of ISS, MSS, Multimedia satellite systems, etc., are needed, as is a Vision to anticipate the future, to set the appropriate scientific and economic base for it (for example, Winston Churchill's forecast of today's Information Society).

Tough real-time decision making is required by the authorities; issues of terrestrial versus space - what to choose, and how to choose - are crucial. In space ventures competitors can also be partners; there is a need for flexibility. It is important to have low-cost access to space to encourage new operators.

A clear definition of roles, for eliminating barriers towards privatisation and commercialisation of space activities is essential.

- Government - long-term R&D, pilot projects, fair non-discriminatory/transparent/harmonised regulations,
- Private - take risks, invest, reap the benefits.

According to K. Doetsch:

Space activity is a microcosm of life - to enable and facilitate a sustainable world. Global/technical/societal/market forces are all leading towards partnerships. Key players are government, manufacturers, service providers, and users.

Opportunities exist, both in the short term (ground segment), and long term: new space activities, such as power, tourism, miniaturisation, etc.). The dictates of a new geopolitical environment call for cooperation and market pull instead of technology push.

According to R. Doré:

Government must move out of some activities as soon as possible and let the market forces take over (e.g. the way in which NASA is privatising some of its activities).

The reason for the success of Arianespace is the fact that there was no significant market for its launchers in Europe, and so it had to go beyond its geographical boundaries and cater to the world needs. The strong message is that success lies in listening to the customer.

The worldwide telecommunications initiative is based on capturing the needs of the people, on frequency allocation, marketing, and developing the right strategies. Technology is not the issue here; it is finance. The need is for every engineer, lawyer, etc., to be able to play the role of a financial person, to pull the necessary funding together.

According to P.I. Yu:

Space activities can be better integrated into the economic mainstream with businesses entering the space arena (e.g. the privatisation of the Shuttle activities).

Reasons for business reluctance include :

- long-term maturity/no short-term benefits, huge investments,
- lack of government initiative in commercialisation/privatisation,
- high risk,
- lack of financial and managerial ability to run space businesses.

To make progress, one has to:

- educate the business community,
- foster the right attitude,
- set the stage for competition and global equilibrium.

According to P. Diamandis:

Like humans, industries go through life-cycles; they grow, they mature, they die, and new industries are born (e.g. the transportation industry's transition from horse-driven coaches, to railroads, to airplanes).

We are conservative about the future and so new developments shock us (consider how the Internet revolutionised the world, how Apple Computers took IBM by storm); today space tourism, or the mining of asteroids might seem far fetched, but tomorrow they might make millionaires.

Other than commercialisation, the basic need of space markets is the need to feed the human spirit, to explore, to go beyond... On Earth, wars have been fought for land, energy and resources; for space, too, similar wars may be fought in the years to come.

According to P. Wood:

The remote sensing market is maturing both in terms of applications and commercialisation; it is being integrated into the economic mainstream especially in the areas of agriculture, fisheries and other land-based activities. Its uses are growing through new products and education of the users; remote sensing is helping to plan and execute land use, urban planning, etc., effectively and efficiently.

Applications like disaster warning and mitigation should not be commercialised in the larger interest of humanity; however, they have implications, in millions and billions of dollars, in the form of human lives, property, etc..

Value-added remote sensing services will take data to the users and attract entrepreneurial efforts.

Many African countries have demonstrated many interesting applications related very directly to economic life. Spot Image is an excellent case of putting evolving technology to work for a robust world market. India has implemented a dramatic remote sensing applications program, through its impressive family of satellites; Argentina, too, is making good use of remote sensing for its people.

According to S. La Pensee:

The need is for applications/goods/services with which the customer can identify. User requirements should be the primary driver in the design of satellites, as is the case of the Indian Space Program: India has achieved the synergy between remote sensing and telecommunictions. The world has a lesson to learn from India. In Europe and the United States, the satellites are first designed/built/and launched and then the users are challenged to use them. That is not logical.

The first need is to understand the markets, their diversity, their range, their specificity in applications (e.g. the mapping market caters for all kinds of maps, for golfing, mining, water resources, transportation, etc.).

GIS is a tool, not a market. Another misconception is the word "low-cost" - in the world of markets it means "cost-effective," not "cheap". It is important to grasp these nuances.

Government dictates the design specifications (in space contracts), tells the supplier exactly what to do and how to do it, with the result that the supplier is excluded from the design process. This is a grave mistake.

It is important to choose the appropriate "client interface". If your client is a farmer, send an agriculturist to talk to him, and if it is a mining company send a geologist. It is very important to be talking the client's language, to tune into, and to understand, the needs of the client.